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(54)【発明の名称】　表面モニター方法、表面積測定方法、半導体装置の製造装置及び方法

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(57)【特許請求の範囲】

【請求項１】　表面にグレインが形成されたアモルファスシリコン膜の表面に光を照射し、その反射光の光強度を測定して前記表面の凹凸を観測する表面モニター方法において、前記光として波長２４０～５００nmの光を用いることを特徴とする表面モニター方法。

【請求項２】　前記アモルファスシリコン膜の表面に膜厚１０nm以下のシリコン窒化膜が形成されていることを特徴とする請求項１の表面モニター方法。

【請求項３】　予め、所定領域に形成された、表面にグレインが形成されたアモルファスシリコン膜の表面積と、前記アモルファスシリコン膜表面に波長２４０～５００nmの光を照射したときの反射光の強度との関係を求めておき、前記アモルファスシリコン膜表面に波長２４０～５００nmの光を照射して、その反射光の強度を測定し、前記アモルファスシリコン膜の表面積を前記表面積と前記反射光との関係に基づいて求めることを特徴とする表面積測定方法。

【請求項４】　前記アモルファスシリコン膜の表面に膜厚１０nm以下のシリコン窒化膜が形成されていることを特徴とする請求項３の表面積測定方法。

【請求項５】　内部を真空にできるチャンバーと、前記チャンバー内に配設された試料保持手段と、前記試料保持手段に保持された試料を加熱するヒーターと、前記試料の所定領域に形成されたアモルファスシリコン膜の表面にグレインを形成するための原料ガスを導入するガス導入手段とを有する半導体装置の製造装置において、前記試料に向けて波長２４０～５００nmの光を照射する光源と、前記試料からの反射光の強度を検出する光検出部とを設け、前記グレインが形成された前記アモルファス

シリコン膜の表面をその場観察できるようにしたことを特徴とする半導体装置の製造装置。

【請求項６】　コンデンサを形成するための電極となるアモルファスシリコン膜の表面にグレインを形成する半導体装置の製造方法において、前記アモルファスシリコン膜の表面に前記グレインを形成するとともに、前記アモルファスシリコン膜の表面に波長２４０～５００nmの光を照射してその反射光の強度を測定し、前記反射光の強度が所定値を下回った時に、前記グレインの形成を終了することを特徴とする半導体装置の製造方法。

【請求項７】　所定領域にアモルファスシリコン膜を形成し、前記アモルファスシリコン膜の表面にグレインを形成する半導体装置の製造方法において、前記アモルファスシリコン膜の表面にグレインを形成するとともに、前記グレインを含む前記アモルファスシリコン膜の表面に波長２４０～５００nmの光を照射してその反射光の強度を測定して当該表面の凹凸を観察する工程を含むことを特徴とする半導体装置の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、薄膜の表面モニター方法に関し、特に、半導体集積回路を作製する際に形成されたシリコン膜の表面をモニターするモニター方法に関する。

【０００２】

【従来の技術】近年、半導体集積回路の高集積化が盛んに試みられており、ＤＲＡＭ（Dynamic Random Access Memory）についても例外ではない。ＤＲＡＭを高集積化するには、単位面積当たりのコンデンサーの数を増やさなければならず、必然的に１つのコンデンサーに与えられる形成面積は小さくなる。コンデンサーの形成面積が縮小すると、コンデンサーの蓄積電荷容量が減少し、α線によるデータの破壊（α線ソフトエラー）等、様々な問題が生じる。そこで、最近では、コンデンサーの構造に工夫を加え、電極表面積を増加させて必要な蓄積電荷容量を確保する試みが成されている。

【０００３】例えば、H.Watanabe等は、“A New stacked capacitor structure using hemispherical-grain poly-silicon electrode”　22nd Conference on Solid Device and Materials, p.873（１９９０）において、コンデンサーの電極表面に、半球状グレイン（ＨＳＧ－Ｓｉ）を形成して、電極表面積を増加させる方法を提案している。この方法は、清浄なシリコン表面における、熱によるシリコン原子のマイグレート現象を利用して、シリコン表面に凹凸を形成する方法である。以下、この方法をＤＲＡＭ（スタック型メモリセル）の製造に利用する場合について図１１を参照して説明する。

【０００４】まず、図１１（ａ）に示すように、高濃度不純物拡散層１０１、素子分離絶縁膜１０２、及びゲート電極１０３が形成されたＰ型シリコン基板１０４上に層間絶縁膜１０５を形成する。そして、リソグラフィー技術及びエッチング技術を用いて、一方の高純度不純物拡散層１０１に到達するコンタクトホールを、層間絶縁膜１０５に形成する。

【０００５】その後、図１１（ｂ）に示すように、減圧ＣＤＶ技術を用いて、コンタクトホール１０６内及び層間絶縁膜１０５上にリンをドーブしたアモルファスシリコン膜１０７を形成する。そして、再びリソグラフィー技術及びエッチング技術を用いて、所定範囲のアモルファスシリコン膜１０７をエッチングし、図１１（ｃ）に示すようにスタック電極１０８を形成する。

【０００６】次に、スタック電極表面のＨＳＧ化を行う。これは、スタック電極１０８を形成した基板１０４を、約５８０℃、約１ｍtorrの減圧下に置き、Si_2H_6ガスに１０分程度晒した後、引き続き等温・等圧にて、N_2雰囲気に３０分程度晒すことによって実現される。この工程により、スタック電極の表面は、図１１（ｄ）に示すように凹凸化され、すなわち、半球状グレイン（ＨＳＧ－Ｓｉ）１０９が形成され、その表面積を増加させることができる。

【０００７】このあと、図１２に示すようにＣＶＤ法を用いて、スタック電極１０８の表面に容量絶縁膜１１１を形成し、ポリシリコンプレート１１２を形成すれば、ＤＲＡＭが得られる。

【０００８】ところで、このスタック電極表面のＨＳＧ化は、前述したように、電極（アモルファスシリコン）表面におけるシリコン原子のマイグレート現象を利用している。このため、電極表面に形成される凹凸の程度は、電極表面への自然酸化膜の付着の度合いによって変化する。詳述すると、電極表面の自然酸化膜が十分に除去されている場合には、図１３（ａ）に示すように、径の大きい半球状グレインが電極表面全体を覆う状態となる。また、自然酸化膜の除去が不十分な場合には、図１３（ｂ）に示すように、小さな半球状グレインが電極表面に散在する状態となる。また、半球状グレインの形成条件を変えることによっても凹凸の程度は変化する。

【０００９】ＤＲＡＭを製品化する場合、各コンデンサーの蓄積電荷容量は、所定の範囲内になければならない。即ち、スタック電極の表面積が所定の範囲内になければならない。しかし、上述のように、スタック電極の表面に形成された凹凸の程度は一定ではなく、様々な状態が考えられる。このため、ＨＳＧ－Ｓｉを用いてシリコン表面に凹凸を形成した後、形成された凹凸の程度の評価を行う必要がある。

【００１０】従来、このような凹凸の程度は、電子顕微鏡を用いた観察により行われたり、実際にコンデンサーを作製して蓄積電荷容量を測定することにより行われている。

【００１１】また、吸着法（例えば、ガス吸着ＢＥＴ多点法）と呼ばれる方法により、表面積を定性的に測定す

ることもできる。

【００１２】また、白色光源からの光を試料表面に入射させ、その表面からの反射光を検出し、反射率の低下から表面の荒れをモニターする方法がある。さらに、単色化されたＸ線を試料表面に全反射臨界角以下で入射させ、鏡面反射方向に配置した検出器で２次Ｘ線の強度を測定する方法も提案されている（特開平４－１５９３３号公報）。

【００１３】

【発明が解決しようとする課題】しかしながら、電子顕微鏡を用いる方法は、観察できる範囲が狭く、試料である半導体ウエハを全面観察することができないという問題点がある。また、半導体ウエハを切片に分割することなく観察できる電子顕微鏡は、一般には測長用であって、その分解能は３００nm程度であり、直径５０nm程度の半球状グレインを観測することができないという問題点がある。

【００１４】また、実際にコンデンサーを形成する方法は、その測定結果の信頼性が高いという特徴があるものの、最も簡単な工程であっても、容量絶縁膜及び上部電極を堆積させて、上部電極及び測定用引き出し線のパターン化を行わなければならず、時間と手間がかかりすぎるという問題点がある。

【００１５】また、吸着法を用いる方法は、吸着させたガスの影響を考えると、実際のＤＲＡＭ製品への適用は困難である。

【００１６】さらに、白色光を用いて反射率を測定する方法では、アモルファスシリコンが可視領域光を透過してしまうため、アモルファスシリコンとその下の膜との界面で反射され、アモルファスシリコンの表面での反射光と干渉する。また、アモルファスシリコンとその下の膜との界面で反射された光は、下の膜の光学特性に依存して変化する。したがって、この方法は、スタック電極の表面に形成された凹凸をモニターするには、信頼性に乏しいという問題点がある。

【００１７】さらにＸ線を用いる方法は、その測定スポットの径をあまり小さくできないという問題点があるだけでなく、試料内部の電子を励起してしまい、コンデンサーのしたのトランジスタのチャネル部分に新たな電子－正孔対を発生させ、デバイスとしての特性を悪化させるという問題点がある。

【００１８】本発明は、容易でありながら信頼性が高く、試料のデバイスとしての特性に悪影響を与えない薄膜の表面モニター方法を提供することを目的とする。

【００１９】

【課題を解決するための手段】本発明によれば、表面にグレインが形成されたアモルファスシリコン膜の表面に光を照射し、その反射光の光強度を測定して前記表面の凹凸を観測する表面モニター方法において、前記光として波長２４０～５００nmの光を用いることを特徴とする表面モニター方法が得られる。

【００２０】また、本発明によれば、予め、所定領域に形成された、表面にグレインが形成されたアモルファスシリコン膜の表面積と、前記アモルファスシリコン膜表面に波長２４０～５００nmの光を照射したときの反射光の強度との関係を求めておき、前記アモルファスシリコン膜表面に波長２４０～５００nmの光を照射して、その反射光の強度を測定し、前記アモルファスシリコン膜の表面積を前記表面積と前記反射光との関係に基づいて求めることを特徴とする表面積測定方法が得られる。

【００２１】さらに、本発明によれば、内部を真空にできるチャンバーと、前記チャンバー内に配設された試料保持手段と、前記試料保持手段に保持された試料を加熱するヒーターと、前記試料の所定領域に形成されたアモルファスシリコン膜の表面にグレインを形成するための原料ガスを導入するガス導入手段とを有する半導体装置の製造装置において、前記試料に向けて波長２４０～５００nmの光を照射する光源と、前記試料からの反射光の強度を検出する光検出部とを設け、前記グレインが形成された前記アモルファスシリコン膜の表面をその場観察できるようにしたことを特徴とする半導体装置の製造装置が得られる。さらにまた、本発明によれば、コンデンサを形成するための電極となるアモルファスシリコン膜の表面にグレインを形成する半導体装置の製造方法において、前記アモルファスシリコン膜の表面に前記グレインを形成するとともに、前記アモルファスシリコン膜の表面に波長２４０～５００nmの光を照射してその反射光の強度を測定し、前記反射光の強度が所定値を下回った時に、前記グレインの形成を終了することを特徴とする半導体装置の製造方法が得られる。また、本発明によれば、所定領域にアモルファスシリコン膜を形成し、前記アモルファスシリコン膜の表面にグレインを形成する半導体装置の製造方法において、前記アモルファスシリコン膜の表面にグレインを形成するとともに、前記グレインを含む前記アモルファスシリコン膜の表面に波長２４０～５００nmの光を照射してその反射光の強度を測定して当該表面の凹凸を観察する工程を含むことを特徴とする半導体装置の製造方法が得られる。

【００２２】

【実施例】以下、図面を参照して本発明の実施例を説明する。図１に本発明の第１の実施例に使用される測定装置を示す。図１に示す測定装置は、試料１１を載置する試料台１２と、光源部１３と、光源部１３からの光を試料１１の表面に照射しその反射光を集光する光軸系部分１４と、光軸径部分１４で集光された反射光を分光する分光器１５と、分光器１５に接続されたデータ処理部１６とを有している。

【００２３】光源部１３は、出射する光の波長を変化させることができる。つまり、この測定装置は、光の波長に応じた試料の反射率を測定することができる。また、

データ処理部１６は、予め、その表面に鏡面研磨等の処理を施した標準シリコン基板等の反射光強度を測定し、その値を反射率１００％として、試料の反射光強度を積分して表示する。

【００２４】この装置を用いて、波長２４０～７５０nmの光に対する、アモルファスシリコンの表面の反射率（破線で示す）と、アモルファスシリコン上にＨＳＧ－Ｓｉを形成した表面の光の反射率（実線で示す）とを測定した。その結果を図２に示す。図２より明らかな通り、いずれの場合も波長５５０nmまでは、波長の増加に伴い反射率が、ほぼ単調に減少する。また、ＨＳＧ－Ｓｉを形成した表面の反射率は、形成しないアモルファスシリコンの表面の反射率よりもかなり小さくなる。また、波長が６００nmを超えると、いずれの場合も反射率が大きく変動する。これは、アモルファスシリコンとその下の膜との界面で反射された光が表面での反射光に干渉するためだと考えられる。この反射率の変動は、アモルファスシリコン膜の膜厚が厚い場合や、結晶化度が高い場合など、屈折率が低くなると波長５５０nm付近から始まる。なお、波長が５５０nm以下の光に対しては、シリコンの光吸収係数が劇的に増大するため、シリコン内に侵入した光はほとんど吸収される。したがって、波長が５５０nm以下の光を用いたときに測定される反射光は、ほぼ１００％が最表面からの反射光である考えられる。

【００２５】上記の結果から、５００nm以下の光を用いれば、アモルファスシリコンの膜質、膜厚、及びアモルファスシリコンの下の膜の状態の影響を受けずに、アモルファスシリコンの表面の凹凸状態を知ることができることが分かる。

【００２６】次に、実際に半導体装置（ＤＲＡＭ）の作製を行なって、スタック電極の表面にＨＳＧ－Ｓｉを形成し、本実施例の測定装置（波長２４０～５００nm）でその反射率を測定した。また、その後、コンデンサーを作製して、蓄積電荷容量の測定を行い、スタック電極の表面積の測定の代わりとした。その結果を図３（ａ）及び（ｂ）に示す。

【００２７】図３（ａ）は、ＨＳＧ－Ｓｉを形成するときの、スタック電極の表面をSi_2H_6ガスに晒した時間と、表面反射率及び蓄積電荷容量との関係を示している（ただし、このあとN_2に１０分間、晒すものとする）。また、図３（ｂ）は、スタック電極の表面をSi_2H_6ガスに（３分間）晒したあと、その表面をN_2に晒した時間と、表面反射率及び蓄積電荷容量との関係を示している。

【００２８】図３（ａ）及び（ｂ）から分かるように、表面反射率と蓄積電荷容量（表面積）との間には、明らかに関連があり、表面反射率が低いほうが、表面積は大きい。また、図３（ａ）は、Si_2H_6ガスに晒す時間を長くしすぎると、表面積が減少することを示している。これは、電極表面に形成されるグレインが、時間経過とともに、図４（ａ）、（ｂ）、及び（ｃ）に示すように、その密度を増し、光源４１からの光が、グレインにより散乱させられる割合が増え、さらに、グレインの形成を続けると、図４（ｄ）に示すよう隣接するグレイン同士が接合してしまって、反射光がディテクター４２に入射するようになるためと考えられる。また、図３（ｂ）は、N_2に晒す時間はある程度より長くしても意味がないことを示している。

【００２９】上記のことから、ＨＳＧ－Ｓｉを形成してスタック電極の表面積を増加させる場合に、本実施例の装置を用いてその表面の反射率を測定してやれば、どのぐらい表面積が増加したか推定できる。例えば、スタック電極の表面積を２倍以上にしようとする場合は、表面反射率が２０％以下であればよい。反射率が２０％を超える場合には、再度ＨＳＧ－Ｓｉを形成する等の処置を行う必要があることが分かる。このように本実施例の測定装置を用いれば、ＤＲＡＭの作製途中で、ＨＳＧ－Ｓｉを形成した後に、コンデンサーの蓄積電荷容量を推定することができる。つまり、測定した反射率が所定値以下であれば、その後作製される半導体装置（ＤＲＡＭ）は、所望のコンデンサー蓄積電荷容量を有することになる。

【００３０】なお、上記実施例では、使用する光の波長を２４０～５００nmとしたが、この範囲の単波長の光、例えば、４８８nm程度のＡｒレーザー光を使用するようにしてもよい。

【００３１】また、本実施例の測定装置では、試料に対して垂直に光を入射させ、垂直反射光を測定するようにしたが、これに限られるものではなく、反射光の検出位置が、入射光の鏡面反射成分を検出する位置であればよい。

【００３２】さらに、本実施例の測定装置は、ＨＳＧ－Ｓｉのモニターに使用したが、他の物質の表面モニターも可能である。

【００３３】次に、本発明の第２の実施例について説明する。第１の実施例では、ＤＲＡＭの作製途中でスタック電極（ＨＳＧ－Ｓｉ）表面の反射率を測定することとしたが、本実施例では、次のようにして反射率の測定を行う。

【００３４】まず、従来と同様にしてスタック電極の表面にＨＳＧ－Ｓｉを形成した後（図８（ｄ）参照）、希ＨＦ溶液中にウエハを浸し、ＨＳＧ化した電極表面の自然酸化膜を除去する。その後ただちに電極表面をアンモニアに晒し、８５０℃のランプ加熱を１分間行う。すると、スタック電極の表面には、図５に示すように、２nm程度のシリコン窒化膜５１が形成される。この後、第１の実施例と同様に、波長２４０～５００nmの光を用いて反射率の測定を行う。このとき、１０nm以下の極めて薄いシリコン窒化膜５１は、反射率の測定にほとんど影響

を与えることはないことが確認された。したがって、反射率が２０％以下であれば、電極の表面積は２倍以上と考えて差支えない。つまり、スタック電極表面の光の反射率を測定することにより、その後作製されるコンデンサーの蓄積電荷容量を推定できる。

【００３５】このあと、容量絶縁膜、及びポリシリコンプレート形成すれば、従来と実質的に同じ半導体装置が得られる。

【００３６】本実施例では、ＨＳＧ化したスタック電極の表面の自然酸化膜を除去し、その後シリコン窒化膜を形成するようにしたことで、スタック電極のＨＳＧ化を行った後、ただちに反射率の測定を行う必要がない。なお、スタック電極のＨＳＧ化を行った後、１週間室温で放置した場合には、自然酸化膜の影響により５％程度の反射率の低下があるが、本実施例の場合、ほとんど低下がみられなかった。

【００３７】次に、本発明の第３の実施例について説明する。本実施例では、枚葉式のＨＳＧ－Ｓｉ形成装置に、測定装置を組み込み、ＨＳＧ－Ｓｉを形成しながら、その反射率の測定を行う。

【００３８】本実施例に使用される装置は、図６に示すように、ガス導入ポート６１及び真空排気ポート６２を有するチャンバー６３と、チャンバー６３に設けられた試料台６４、ヒーター６５、波長３６５nmの光を出射する光源６６、及びディテクター６７を有している。

【００３９】この装置でＨＳＧ－Ｓｉを形成する場合は、まず、真空に保持されたチャンバー６３内に、清浄な非晶質シリコン表面（スタック電極）を有する試料６８を導入する。そして、ヒーター６５で試料６８を加熱する。その温度は例えば、５８０℃とする。次に、ガス導入ポート６１からSi_2H_6ガスを１０分間導入する。このときチャンバー６３内の圧力が１ｍtorrとなるように調整する。次に、Si_2H_6ガスの導入を停止し、チャンバー６３内のSi_2H_6ガスを真空排気ポート６２から排気して、試料の温度を保持すれば、試料は真空中でアニールされ、表面にＨＳＧ－Ｓｉが形成される。

【００４０】本実施例では、ＨＳＧ－Ｓｉを形成しながらの、その場観察が可能である。この観察は、チャンバー７３への試料導入時から行うこともできるし、適当な時期（例えば、アニールを開始するとき）に開始するようにしてもよい。観測は、光源６６からの光を試料６８に照射し、その反射光をディテクターで検出して行う。観測結果の一例を図７に示す。図７において、期間Ａは、試料導入及び昇温期間を、期間Ｂは、Si_2H_6導入期間を、期間Ｃは、アニール処理期間を示す。

【００４１】図７から明らかなように、反射光の強度は、アニール工程が始まると急激に減少し、その後飽和する。図のＣ１、Ｃ２、Ｃ３、及びＣ４の各時点でアニール処理を終了する４つの試料を作製し、その表面を電子顕微鏡で観察した。その結果を図８（ａ）、（ｂ）、（ｃ）、及び（ｄ）に示す。ここで、図８（ａ）、（ｂ）、（ｃ）、及び（ｄ）は、それぞれ図７のＣ１、Ｃ２、Ｃ３、及びＣ４でアニールを終了した試料に対応する。

【００４２】図８（ａ）、（ｂ）、及び（ｃ）に示すように、反射光の強度の減少（Ｃ１→Ｃ２→Ｃ３）に伴う、ＨＳＧ－Ｓｉのグレインサイズが増大が観測できた。また、図８（ｃ）及び（ｄ）に示すように、反射光の強度が飽和する領域（Ｃ３→Ｃ４）では、ＨＳＧ－Ｓｉのグレインサイズの変化はみられなかった。また、これらの試料を用いてコンデンサーを作製し、その蓄積電荷容量を測定した。その結果を図９に示す。図９に示すように、反射光の強度が減少（Ｃ１→Ｃ２→Ｃ３）する領域では、蓄積電荷容量の急激な増大がみられ、反射光の強度が飽和する領域（Ｃ３→Ｃ４）では、蓄積電荷容量も飽和する。

【００４３】このように、本実施例では、ＨＳＧ－Ｓｉを形成しながら、その場観察が可能で、測定した反射率からコンデンサーを作製したときの蓄積電荷容量を推定することができる。

【００４４】なお、上記実施例では、波長３６５nmの光を用いたが、２４０～５００nmの範囲内であれば、他の波長の光でもよい。また、単波長の光ではなく、ある範囲を有する波長帯の光を用いてもよい。

【００４５】また、上記実施例では、枚葉式装置に測定装置を組み込んだ例について説明したが、図１０に示すように、ホットウォール構造のバッチ処理装置に組み込むこともできる。ここで、図１０の装置において、図６と機能的に同一のものには同一番号を付してある。

【００４６】

【発明の効果】本発明によれば、２４０～５００nmの光を用いたことで、容易かつ精度良く、アモルファスシリコン膜の表面の凹凸をモニターすることができるまた、このように光を用いることで、試料のデバイスとしての特性に悪影響を与えるようなこともない。

【００４７】また、光源及び検出部を半導体製造装置に組み込むことで、その場観察が可能で、処理時間が短縮され、スループットの向上が図れる。

【図面の簡単な説明】

【図１】本発明の第１の実施例に使用される測定装置の概略図である。

【図２】図１の装置を用いて測定した、光の波長と、半球状グレインを形成する前及び後のアモルファスシリコンの表面の反射率との関係を示すグラフである。

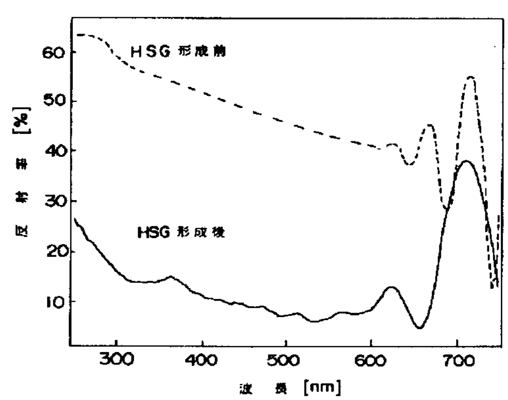
【図３】図１の装置を用いて測定した、各工程の処理時間と反射率との関係と、各工程の処理時間とその後作製したコンデンサーの蓄積電荷容量との関係とを示すグラフであって、（ａ）は、Si_2H_6に晒す時間を変化させた場合、（ｂ）は、N_2雰囲気下での熱処理時間を変

化させた場合を示す。
【図４】半球状グレインの形成状態と反射率のとの関係を説明するための概念図であって、（ａ）はグレインが低密度の場合、（ｂ）はグレインが中密度の場合、（ｃ）はグレインが高密度の場合をそれぞれ示し、（ｄ）は隣接するグレイン同士が接合した場合を示す。
【図５】本発明の第２の実施例を説明するための作成中のＤＲＡＭの断面模式図である。
【図６】本発明の第３の実施例に使用され半導体製造装置の概略図である。
【図７】図６の装置を用いて測定したグレイン形成時間と表面反射率との関係を示すグラフである。
【図８】（ａ）、（ｂ）、（ｃ）、及び（ｄ）は、それぞれ図７のＣ１、Ｃ２、Ｃ３、及びＣ４の時点の電極の表面に形成されたグレインの粒子構造の顕微鏡写真である。
【図９】アニール時間と蓄積電荷容量との関係を示すグラフである。
【図１０】本発明の第３の実施例に使用できる他の半導体製造装置の概略図である。
【図１１】従来のＤＲＡＭの製造工程を説明するための工程図である。
【図１２】ＤＲＡＭの構造を示す断面模式図である。
【図１３】電極の表面に形成されたグレインの粒子構造の顕微鏡写真であって、（ａ）は電極表面の自然酸化膜を十分に除去したあとグレインを形成した場合、（ｂ）は電極表面の自然酸化膜を十分に除去せずにグレインを形成した場合を示す。

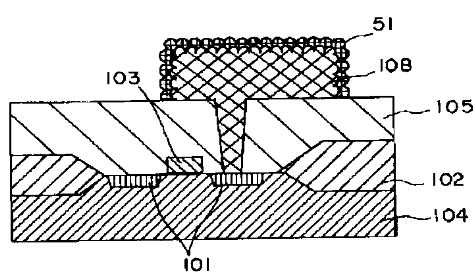
【符号の説明】

１１	試料
１２	試料台
１３	光源部
１４	光軸系部分
１５	分光器
１６	データ処理部
４１	光源
４２	ディテクター
５１	シリコン窒化膜
６１	ガス導入ポート
６２	真空排気ポート
６３	チャンバー
６４	試料台
６５	ヒーター
６６	光源
６７	ディテクター
６８	試料
１０１	高濃度不純物拡散層
１０２	素子分離絶縁膜
１０３	ゲート電極
１０４	Ｐ型シリコン基板
１０５	層間絶縁膜
１０６	コンタクトホール
１０７	アモルファスシリコン膜
１０８	スタック電極
１０９	半球状グレイン（ＨＳＧ－Ｓｉ）

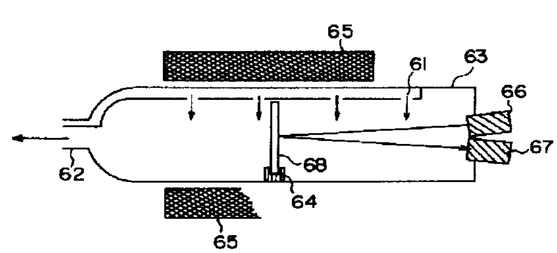
【図２】



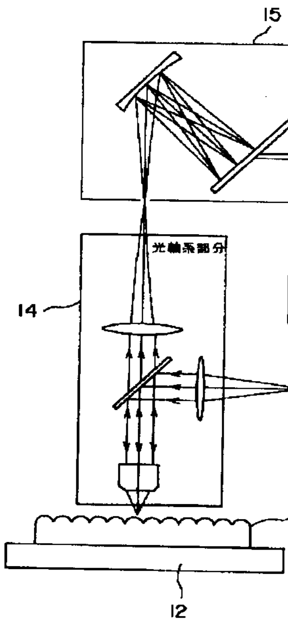
【図５】



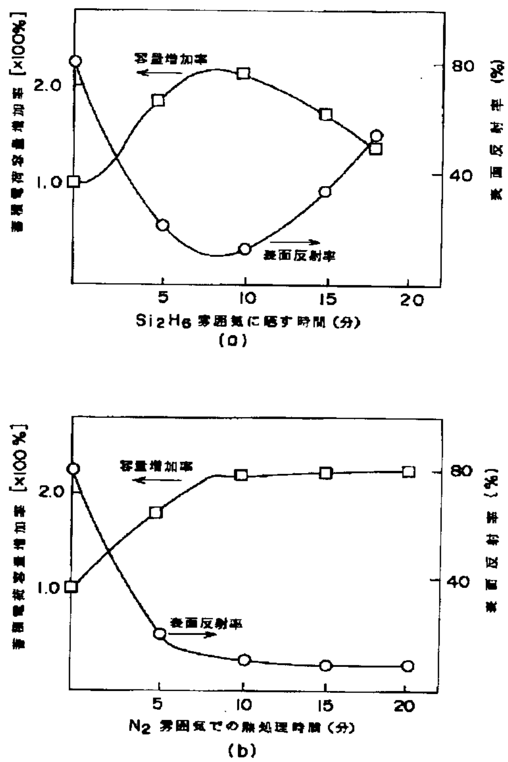
【図１０】



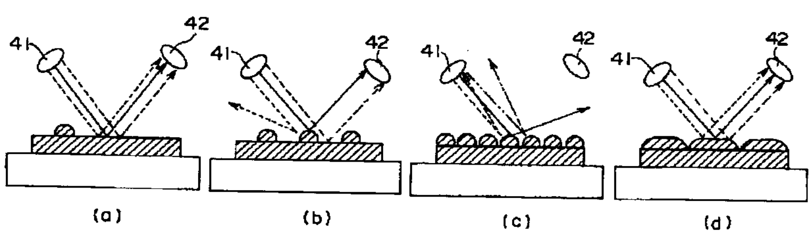
【図１】



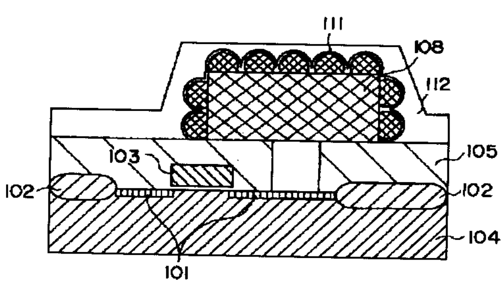
【図３】



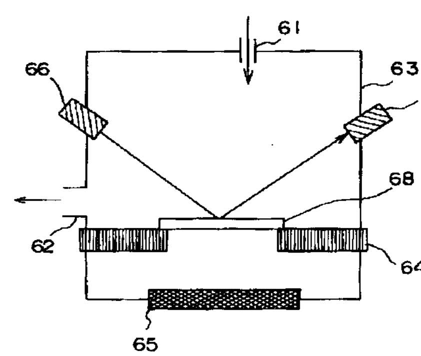
【図４】



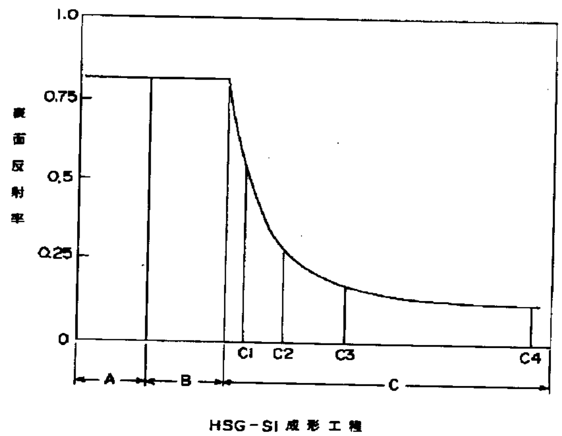
【図１２】



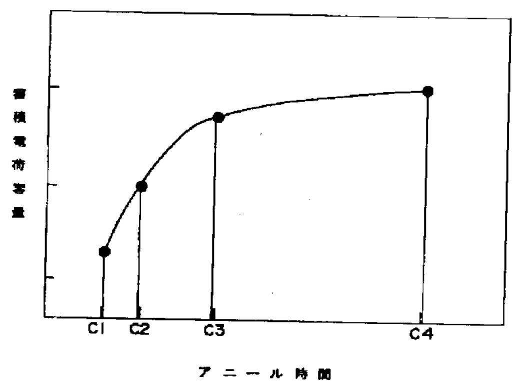
【図６】



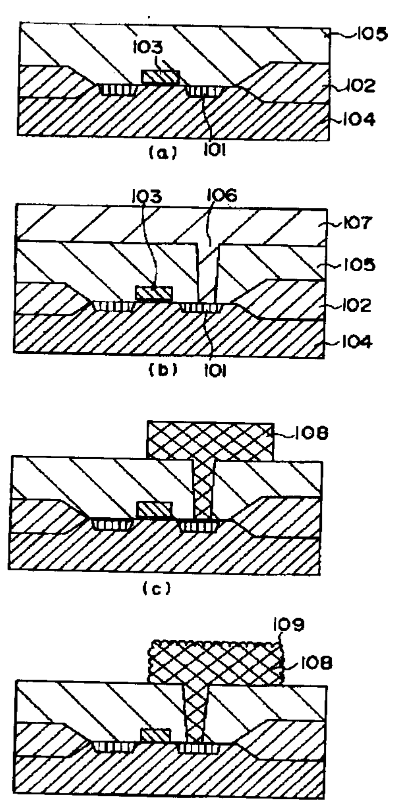
【図７】


1.0
0.75
0.5
0.25
0
表面反射率
C1
C2
C3
C4
A
B
C
HSG−SI成形工程

【図９】

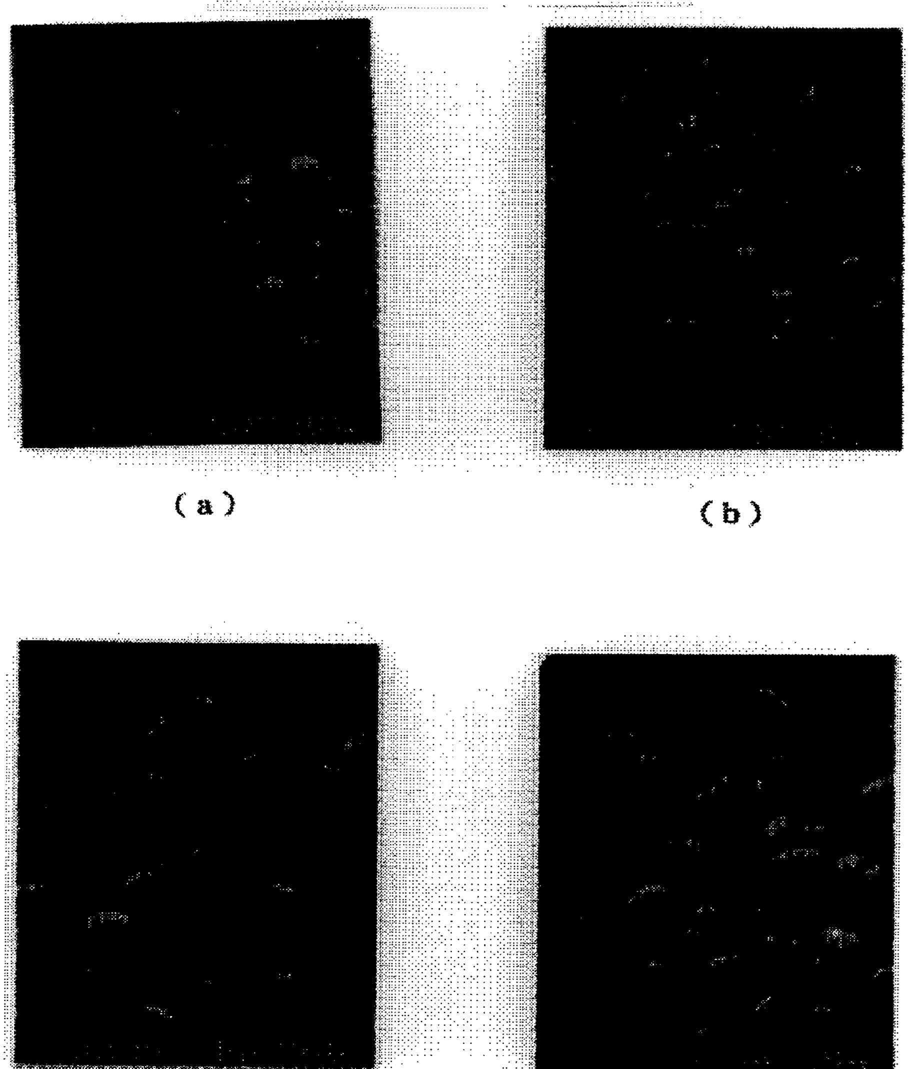

蓄積電荷容量
C1
C2
C3
C4
アニール時間

【図１１】


103
105
102
104
(a)
101
103
106
107
105
102
104
(b)
101
108
(c)
109
108

【図8】

図面代用写真



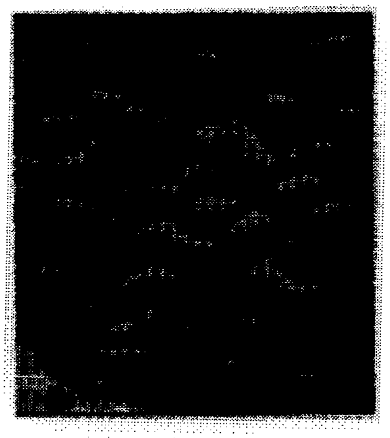
（a）　（b）

（c）　（d）

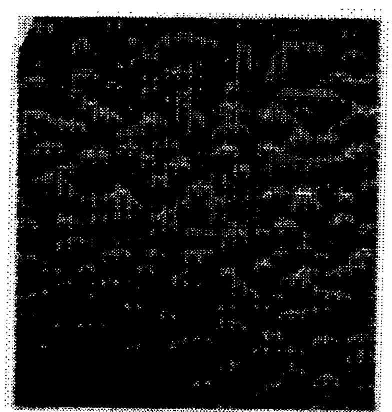
写　真

【図１３】

図面代用写真



（ａ）



（ｂ）

写　　　真

JP,2638554,B
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CLAIMS

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(57) [Claim(s)]

[Claim 1] The surface monitor approach characterized by using light with a wavelength of 240-500nm as said light in the surface monitor approach which irradiates light on the front face of the amorphous silicon film with which a grain was formed in the front face, measures the optical reinforcement of the reflected light, and observes the irregularity of said front face.
[Claim 2] The surface monitor approach of claim 1 characterized by forming the silicon nitride of 10nm or less of thickness in the front face of said amorphous silicon film.
[Claim 3] The surface area of the amorphous silicon film which was beforehand formed in the predetermined field and with which a grain was formed in the front face, Ask said amorphous silicon film front face for relation with the reinforcement of the reflected light when irradiating light with a wavelength of 240-500nm, and light with a wavelength of 240-500nm is irradiated on said amorphous silicon film front face. The surface area measuring method characterized by measuring the reinforcement of the reflected light and asking for the surface area of said amorphous silicon film based on the relation of said surface area and said reflected light.
[Claim 4] The surface area measuring method of claim 3 characterized by forming the silicon nitride of 10nm or less of thickness in the front face of said amorphous silicon film.
[Claim 5] The chamber as for which the interior is made to a vacuum, and the sample maintenance means arranged in said chamber, In the manufacturing installation of a semiconductor device which has a gas installation means to introduce the material gas for forming a grain in the front face of the heater which heats the sample held at said sample maintenance means, and the amorphous silicon film formed in the predetermined field of said sample The manufacturing installation of the semiconductor device characterized by the ability to carry out the in situ observation of the front face of said amorphous silicon film in which the

light source which irradiates light with a wavelength of 240-500nm towards said sample, and the photodetection section which detects the reinforcement of the reflected light from said sample were prepared, and said grain was formed.

[Claim 6] In the manufacture approach of the semiconductor device which forms a grain in the front face of the amorphous silicon film used as the electrode for forming a capacitor, while forming said grain in the front face of said amorphous silicon film The manufacture approach of the semiconductor device characterized by ending formation of said grain when light with a wavelength of 240-500nm is irradiated on the front face of said amorphous silicon film, the reinforcement of the reflected light is measured and the reinforcement of said reflected light is less than a predetermined value.

[Claim 7] The manufacture approach of the semiconductor device characterized by including the process which irradiates light with a wavelength of 240-500nm on the front face of said amorphous silicon film containing said grain, measures the reinforcement of the reflected light, and observes the irregularity of the front face concerned in the manufacture approach of the semiconductor device which forms the amorphous silicon film in a predetermined field, and forms a grain in the front face of said amorphous silicon film while forming a grain in the front face of said amorphous silicon film.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] Especially this invention relates to the monitor approach which acts as the monitor of the front face of the silicone film formed when producing a semiconductor integrated circuit about the surface monitor approach of a thin film.

[0002]

[Description of the Prior Art] In recent years, high integration of a semiconductor integrated circuit is tried briskly, and is not an exception about DRAM (Dynamic Random Access Memory), either. In order to integrate DRAM highly, the number of the capacitors per unit area must be increased, and the formation area inevitably given to one capacitor becomes small. If the formation area of a capacitor contracts, the stored charge capacity of a capacitor will decrease and various problems, such as destruction (alpha-rays soft error) of the data based on alpha rays, will arise. So, recently, a device is added to the structure of a capacitor and the attempt which is

made to increase an electrode surface product and secures a required stored charge capacity has accomplished.

[0003] For example, H.Watanabe etc. is "A New stacked capacitor structure using hemispherical-grain poly-silicon electrode". In 22 nd Conference on Solid Device and Materials and p.873 (1990), a hemispherical grain (HSG-Si) was formed in the electrode surface of a capacitor, and the approach to which an electrode surface product is made to increase is proposed. This approach is the approach of forming irregularity in a silicon front face using the my great phenomenon of the silicon atom by heat in a pure silicon front face. Hereafter, this approach is explained with reference to drawing 11 about the case where it uses for manufacture of DRAM (stack mold memory cell).

[0004] First, as shown in drawing 11 (a), an interlayer insulation film 105 is formed on the high concentration impurity diffused layer 101, the isolation insulator layer 102, and the P type silicon substrate 104 in which the gate electrode 103 was formed. And the contact hole which reaches one high grade impurity diffused layer 101 is formed in an interlayer insulation film 105 using a lithography technique and an etching technique.

[0005] Then, as shown in drawing 11 (b), the amorphous silicon film 107 which doped Lynn is formed in a contact hole 106 and on an interlayer insulation film 105 using a reduced pressure CDV technique. And again, using a lithography technique and an etching technique, the amorphous silicon film 107 of the predetermined range is etched, and as shown in drawing 11 (c), the stack electrode 108 is formed.

[0006] Next, HSG-ization of a stack electrode surface is performed. the substrate 104 with which this formed the stack electrode 108 -- the bottom of about 580 degrees C and reduced pressure of about 1 mtorr -- placing -- Si two H6 after exposing to gas about 10 minutes -- succeedingly -- isothermal - isotonic -- ** and N2 It realizes by exposing to an ambient atmosphere about 30 minutes. As shown in drawing 11 (d), it is irregularity-ized by this process, namely, the hemispherical grain (HSG-Si) 109 is formed of it, and the front face of a stack electrode can make that surface area increase according to it.

[0007] Then, DRAM will be obtained if the capacity insulator layer 111 is formed in the front face of the stack electrode 108 using a CVD method as shown in drawing 12 , and the polysilicon comp rate 112 is formed.

[0008] By the way, as HSG-ization of this stack electrode surface was mentioned above, the my

great phenomenon of the silicon atom in an electrode (amorphous silicon) front face is used. For this reason, extent of the irregularity formed in an electrode surface changes with the degrees of adhesion of the natural oxidation film to an electrode surface. If it explains in full detail, when the natural oxidation film of an electrode surface is fully removed, as shown in drawing 13 (a), the large hemispherical grain of a path will be in a wrap condition about the whole electrode surface. Moreover, when clearance of the natural oxidation film is inadequate, as shown in drawing 13 (b), a small hemispherical grain will be in the condition that it is scattered in an electrode surface. Moreover, concavo-convex extent changes also by changing the formation conditions of a hemispherical grain.

[0009] When producing DRAM commercially, there must be stored charge capacity of each capacitor within the limits of predetermined. That is, there must be surface area of a stack electrode within the limits of predetermined. However, as mentioned above, extent of the irregularity formed in the front face of a stack electrode can consider various conditions rather than is fixed. For this reason, after forming irregularity in a silicon front face using HSG-Si, it is necessary to evaluate extent of the formed irregularity.

[0010] Conventionally, extent of such irregularity is performed by being performed by the observation which used the electron microscope, or producing a capacitor actually and measuring stored charge capacity.

[0011] Moreover, surface area can also be qualitatively measured by the approach called an adsorption process (for example, gas adsorption BET multipoint method).

[0012] Moreover, a sample front face is made to carry out incidence of the light from the source of the white light, the reflected light from the front face is detected, and there is the approach of acting as the monitor of the surface dry area from decline in a reflection factor. Furthermore, a sample front face is made to carry out incidence of the monochrome-ized X-ray below by the total reflection critical angle, and the approach of measuring the reinforcement of a secondary X-ray with the detector arranged in the direction of specular reflection is also proposed (JP,4-15933,A).

[0013]

[Problem(s) to be Solved by the Invention] However, the observable range of the approach using an electron microscope is narrow, and it has the trouble that the semi-conductor wafer which is a sample is completely unobservable. Moreover, generally the electron microscope which can be

observed without dividing a semi-conductor wafer into an intercept is an object for length measurement, and the resolution is about 300nm and has the trouble that a hemispherical grain with a diameter of about 50nm cannot be observed.
[0014] Moreover, although the approach of forming a capacitor actually has the description that the dependability of the measurement result is high, even if it is the easiest process, it makes a capacity insulator layer and an up electrode deposit, must perform patternizing of an up electrode and the outgoing line for measurement, and has the trouble of taking time amount and time and effort too much.
[0015] Moreover, if the approach using an adsorption process considers the effect of gas made to adsorb, application for a actual DRAM product is difficult.
[0016] Furthermore, by the approach of measuring a reflection factor using the white light, in order that an amorphous silicon may penetrate visible region light, it is reflected by the interface of an amorphous silicon and the film under it, and interferes with the reflected light in the front face of an amorphous silicon. Moreover, the light reflected by the interface of an amorphous silicon and the film under it changes depending on the optical property of the lower film. Therefore, this approach has the trouble of being scarce in dependability, in order to act as the monitor of the irregularity formed in the front face of a stack electrode.
[0017] Furthermore, the approach using an X-ray excites the electron inside a sample, makes the channel part of a carrying-out [the capacitor] transistor there to be not only a trouble that the path of the measurement spot cannot be made not much small, but generate a new electronic-electron hole pair, and has the trouble of worsening the property as a device.
[0018] Though it is easy, it is reliable, and this invention aims at offering the surface monitor approach of a thin film of not having an adverse effect on the property as a device of a sample.
[0019]
[Means for Solving the Problem] According to this invention, light is irradiated on the front face of the amorphous silicon film with which a grain was formed in the front face, and the surface monitor approach characterized by using light with a wavelength of 240-500nm as said light is acquired in the surface monitor approach which measures the optical reinforcement of the reflected light and observes the irregularity of said front face.
[0020] Moreover, the surface area of the amorphous silicon film which was beforehand formed in the predetermined field according to this invention and with which a grain was formed in the

front face, Ask said amorphous silicon film front face for relation with the reinforcement of the reflected light when irradiating light with a wavelength of 240-500nm, and light with a wavelength of 240-500nm is irradiated on said amorphous silicon film front face. The reinforcement of the reflected light is measured and the surface area measuring method characterized by asking for the surface area of said amorphous silicon film based on the relation of said surface area and said reflected light is acquired.

[0021] Furthermore, the sample maintenance means which was arranged in the chamber as for which the interior is made to a vacuum, and said chamber according to this invention, In the manufacturing installation of a semiconductor device which has a gas installation means to introduce the material gas for forming a grain in the front face of the heater which heats the sample held at said sample maintenance means, and the amorphous silicon film formed in the predetermined field of said sample The light source which irradiates light with a wavelength of 240-500nm towards said sample, and the photodetection section which detects the reinforcement of the reflected light from said sample are prepared. The manufacturing installation of the semiconductor device characterized by the ability to carry out the in situ observation of the front face of said amorphous silicon film in which said grain was formed is obtained. In the manufacture approach of the semiconductor device which forms a grain in the front face of the amorphous silicon film which serves as an electrode for forming a capacitor further again according to this invention While forming said grain in the front face of said amorphous silicon film When light with a wavelength of 240-500nm is irradiated on the front face of said amorphous silicon film, the reinforcement of the reflected light is measured and the reinforcement of said reflected light is less than a predetermined value, the manufacture approach of the semiconductor device characterized by ending formation of said grain is acquired. Moreover, according to this invention, it sets to the manufacture approach of the semiconductor device which forms the amorphous silicon film in a predetermined field, and forms a grain in the front face of said amorphous silicon film. While forming a grain in the front face of said amorphous silicon film The manufacture approach of the semiconductor device characterized by including the process which irradiates light with a wavelength of 240-500nm on the front face of said amorphous silicon film containing said grain, measures the reinforcement of the reflected light, and observes the irregularity of the front face concerned is acquired.

[0022]

[Example] Hereafter, the example of this invention is explained with reference to a drawing. The measuring device used for drawing 1 by the 1st example of this invention is shown. The measuring device shown in drawing 1 has the sample base 12 in which a sample 11 is laid, the light source section 13, the optical-axis system part 14 which irradiates the light from the light source section 13 on the front face of a sample 11, and condenses the reflected light, the spectroscope 15 which carries out the spectrum of the reflected light condensed by part for the optical-axis diameter 14, and the data-processing section 16 connected to the spectroscope 15.
[0023] The light source section 13 can change the wavelength of the light which carries out outgoing radiation. That is, this measuring device can measure the reflection factor of the sample according to the wavelength of light. Moreover, the data-processing section 16 measures beforehand reflected light reinforcement, such as a standard silicon substrate which processed mirror polishing etc. on the front face, and integrates with and displays the reflected light reinforcement of a sample by making the value into 100% of reflection factors.
[0024] The reflection factor (a broken line shows) of the front face of an amorphous silicon to light with a wavelength of 240-750nm and the reflection factor (a continuous line shows) of the light of the front face in which HSG-Si was formed on the amorphous silicon were measured using this equipment. The result is shown in drawing 2 . In any case, it decreases from drawing 2 almost in monotone [a reflection factor] with the increment in wavelength to the wavelength of 550nm a clear passage. Moreover, the reflection factor of the front face in which HSG-Si was formed becomes quite smaller than the reflection factor of the front face of the amorphous silicon which is not formed. Moreover, if wavelength exceeds 600nm, in any case, a reflection factor will be changed sharply. This is considered to be for the light reflected by the interface of an amorphous silicon and the film under it to interfere in the reflected light in a front face. When the thickness of the amorphous silicon film is thick, or when degree of crystallinity is high, fluctuation of this reflection factor will begin from near the wavelength of 550nm, if a refractive index becomes low. In addition, since the optical absorption multiplier of silicon increases [wavelength] dramatically to light 550nm or less, most light which invaded in silicon is absorbed. therefore, about 100% of the reflected light measured when wavelength uses light 550nm or less is the reflected light from the outermost surface -- it thinks.
[0025] It turns out that the concavo-convex condition of the front face of an amorphous silicon can be known, without being influenced by the above-mentioned result of the condition of the

membraneous quality of an amorphous silicon, thickness, and the film under an amorphous silicon, if light 500nm or less is used.

[0026] Next, the semiconductor device (DRAM) was produced actually, HSG-Si was formed in the front face of a stack electrode, and the reflection factor was measured with the measuring device (wavelength of 240-500nm) of this example. Moreover, after that, the capacitor was produced, stored charge capacity was measured and it considered as instead of [of measurement of the surface area of a stack electrode]. The result is shown in drawing 3 (a) and (b).

[0027] Drawing 3 (a) is the front face of a stack electrode when forming HSG-Si Si2H6 The relation between the time amount exposed to gas, and a surface reflection factor and stored charge capacity is shown (however, it shall expose to N2 for 10 minutes after this). Moreover, drawing 3 (b) is Si two H6 about the front face of a stack electrode. It is the front face after exposing to gas (for 3 minutes) N2 The relation between the exposed time amount, and a surface reflection factor and stored charge capacity is shown.

[0028] Relation is between a surface reflection factor and stored charge capacity (surface area) clearly, and the one of surface area where a surface reflection factor is lower is large so that drawing 3 (a) and (b) may show. Moreover, drawing 3 (a) is Si two H6. If time amount exposed to gas is lengthened too much, it is shown that surface area decreases. The rate of this that increase and the light from the light source 41 are scattered by the grain in the consistency as the grain formed in an electrode surface shows drawing 4 (a), (b), and (c) with time amount progress increases, and further, the grains which adjoin as shown in drawing 4 (d) if formation of a grain is continued join, and it thinks for the reflected light to come to carry out incidence to a detector 42. Moreover, drawing 3 (b) is N2. It is shown that it is meaningless even if it lengthens time amount to expose to some extent more.

[0029] if the equipment of this example is used and the reflection factor of the front face is measured, when forming HSG-Si and making the surface area of a stack electrode increase from the above-mentioned thing -- which -- about -- it can presume whether surface area increased. For example, when it is going to double [more than] the surface area of a stack electrode, a surface reflection factor should just be 20% or less. When a reflection factor exceeds 20%, it turns out that it is necessary to deal with forming HSG-Si again etc. Thus, if the measuring device of this example is used, it is in the middle of production of DRAM, and after forming HSG-Si, the stored charge capacity of a capacitor can be presumed. That is, if the measured

reflection factor is below a predetermined value, the semiconductor device (DRAM) produced after that will have a desired capacitor stored charge capacity.

[0030] In addition, although wavelength of the light to be used was set to 240-500nm in the above-mentioned example, you may make it use the light of the single wavelength of this range, for example, about 488nm Ar laser light.

[0031] Moreover, although incidence of the light is vertically carried out to a sample and the vertical reflected light was measured in the measuring device of this example, it is not restricted to this and the detection location of the reflected light should just be a location which detects the specular reflection component of incident light.

[0032] Furthermore, although the measuring device of this example was used for the monitor of HSG-Si, the surface monitor of other matter is also possible.

[0033] Next, the 2nd example of this invention is explained. Although [the 1st example] it is in the middle of production of DRAM and the reflection factor of a stack electrode (HSG-Si) front face is measured, in this example, a reflection factor is measured as follows.

[0034] First, after forming HSG-Si in the front face of a stack electrode as usual (refer to drawing 8 (d)), a wafer is dipped into a rare HF solution and the natural oxidation film of the electrode surface which turned HSG is removed. An electrode surface is immediately exposed to ammonia after that, and 850-degree C lamp heating is performed for 1 minute. Then, as shown in drawing 5 , the about 2nm silicon nitride 51 is formed in the front face of a stack electrode. Then, a reflection factor is measured like the 1st example using light with a wavelength of 240-500nm. At this time, it was checked that the very thin silicon nitride 51 10nm or less hardly affects measurement of a reflection factor. Therefore, if a reflection factor is 20% or less, the surface area of an electrode will be considered to be more than twice, and will not interfere. That is, the stored charge capacity of the capacitor produced after that can be presumed by measuring the reflection factor of the light of a stack electrode surface.

[0035] then, a capacity insulator layer -- and if polysilicon comp rate formation is carried out, the same semiconductor device will be obtained as substantially as the former.

[0036] The natural oxidation film of the front face of the stack electrode which turned HSG is removed, and by having formed the silicon nitride after that, immediately after performing HSG-ization of a stack electrode, it is not necessary to measure a reflection factor at this example. In addition, although there was decline in about 5% of reflection factor under the effect of the

natural oxidation film when it was left at a room temperature for one week after performing HSG-ization of a stack electrode, in the case of this example, lowering was hardly seen.

[0037] Next, the 3rd example of this invention is explained. The reflection factor is measured in this example, building a measuring device into the HSG-Si formation equipment of single wafer processing, and forming HSG-Si.

[0038] The equipment used for this example has the sample base 64 established in the chamber 63 which has the gas installation port 61 and the evacuation port 62, and the chamber 63, a heater 65, the light source 66 which carries out outgoing radiation of the light with a wavelength of 365nm, and a detector 67, as shown in drawing 6 .

[0039] When forming HSG-Si with this equipment, the sample 68 which has a pure amorphous silicon front face (stack electrode) is first introduced in the chamber 63 held at the vacuum. And a sample 68 is heated at a heater 65. The temperature is made into 580 degrees C. Next, the gas installation port 61 to Si two H6 Gas is introduced for 10 minutes. It adjusts so that the pressure in a chamber 63 may serve as 1mtorr at this time. Next, Si two H6 Installation of gas is suspended and it is Si two H6 in a chamber 63. If gas is exhausted from the evacuation port 62 and the temperature of a sample is held, annealing of the sample will be carried out in a vacuum, and HSG-Si will be formed in a front face.

[0040] In this example, in situ observation while forming HSG-Si is possible. This observation can also be performed from the time of the sample installation to a chamber 73, and you may make it start at a suitable stage (for example, when starting annealing). Observation irradiates the light from the light source 66 at a sample 68, and is performed by a detector detecting the reflected light. An example of observation is shown in drawing 7 . Setting to drawing 7 , for Period A, Period B is Si two H6 about sample installation and a warm up period. Period C shows an annealing treatment period for an introductory period.

[0041] If an annealing process starts, the reinforcement of the reflected light will decrease rapidly and will be saturated after that, so that clearly from drawing 7 . Each [of C1, C2, C3, and C4 of drawing] four samples which end annealing treatment at the event were produced, and the front face was observed with the electron microscope. The result is shown in drawing 8 (a), (b), (c), and (d). Here, drawing 8 (a), (b), (c), and (d) correspond to the sample which ended annealing by C1, C2, C3, and C4 of drawing 7 , respectively.

[0042] As shown in drawing 8 (a), (b), and (c), the grain size of HSG-Si accompanying the

strength reduction (C1 ->C2 ->C3) of the reflected light has observed buildup. Moreover, as shown in drawing 8 (c) and (d), change of the grain size of HSG-Si was not seen in the field (C3 ->C4) in which the reinforcement of the reflected light is saturated. Moreover, the capacitor was produced using these samples and the stored charge capacity was measured. The result is shown in drawing 9 . As shown in drawing 9 , rapid buildup of stored charge capacity is seen in the field in which the reinforcement of the reflected light decreases (C1 ->C2 ->C3), and stored charge capacity is also saturated with the field (C3 ->C4) in which the reinforcement of the reflected light is saturated.

[0043] Thus, in this example, forming HSG-Si, in situ observation is possible and the stored charge capacity when producing a capacitor from the measured reflection factor can be presumed.

[0044] In addition, although light with a wavelength of 365nm was used in the above-mentioned example, as long as it is within the limits of 240-500nm, the light of other wavelength is sufficient. Moreover, not the light of single wavelength but the light of the wavelength range which has a certain range may be used.

[0045] Moreover, although the above-mentioned example explained the example which built the measuring device into single-wafer-processing equipment, as shown in drawing 10 , it is also incorporable into the batch-processing equipment of hot wall structure. Here, in the equipment of drawing 10 , the same number is given to drawing 6 and a functional target at the same thing.

[0046]

[Effect of the Invention] According to this invention, by having used 240-500nm light, it is accurate and there are not easy and a thing which has an adverse effect on the property as a device of a sample by the thing which can act as the monitor of the irregularity of the front face of the amorphous silicon film, and for which light is used in this way again, either.

[0047] Moreover, by including the light source and a detecting element in semiconductor fabrication machines and equipment, in situ observation is possible, the processing time is shortened, and improvement in a throughput can be aimed at.

TECHNICAL FIELD

[Industrial Application] Especially this invention relates to the monitor approach which acts as the monitor of the front face of the silicone film formed when producing a semiconductor integrated circuit about the surface monitor approach of a thin film.

PRIOR ART

[Description of the Prior Art] In recent years, high integration of a semiconductor integrated circuit is tried briskly, and is not an exception about DRAM (Dynamic Random Access Memory), either. In order to integrate DRAM highly, the number of the capacitors per unit area must be increased, and the formation area inevitably given to one capacitor becomes small. If the formation area of a capacitor contracts, the stored charge capacity of a capacitor will decrease and various problems, such as destruction (alpha-rays soft error) of the data based on alpha rays, will arise. So, recently, a device is added to the structure of a capacitor and the attempt which is made to increase an electrode surface product and secures a required stored charge capacity has accomplished.

[0003] For example, H.Watanabe etc. is "A New stacked capacitor structure using hemispherical-grain poly-silicon electrode". In 22 nd Conference on Solid Device and Materials and p.873 (1990), a hemispherical grain (HSG-Si) was formed in the electrode surface of a capacitor, and the approach to which an electrode surface product is made to increase is proposed. This approach is the approach of forming irregularity in a silicon front face using the my great phenomenon of the silicon atom by heat in a pure silicon front face. Hereafter, this approach is explained with reference to drawing 11 about the case where it uses for manufacture of DRAM (stack mold memory cell).

[0004] First, as shown in drawing 11 (a), an interlayer insulation film 105 is formed on the high concentration impurity diffused layer 101, the isolation insulator layer 102, and the P type silicon substrate 104 in which the gate electrode 103 was formed. And the contact hole which reaches one high grade impurity diffused layer 101 is formed in an interlayer insulation film 105 using a lithography technique and an etching technique.

[0005] Then, as shown in drawing 11 (b), the amorphous silicon film 107 which doped Lynn is formed in a contact hole 106 and on an interlayer insulation film 105 using a reduced pressure CDV technique. And again, using a lithography technique and an etching technique, the amorphous silicon film 107 of the predetermined range is etched, and as shown in drawing 11 (c), the stack electrode 108 is formed.

[0006] Next, HSG-ization of a stack electrode surface is performed. the substrate 104 with which this formed the stack electrode 108 -- the bottom of about 580 degrees C and reduced pressure of about 1 mtorr -- placing -- Si two H6 after exposing to gas about 10 minutes -- succeedingly --

isothermal - isotonic -- ** and N2 It realizes by exposing to an ambient atmosphere about 30 minutes. As shown in drawing 11 (d), it is irregularity-ized by this process, namely, the hemispherical grain (HSG-Si) 109 is formed of it, and the front face of a stack electrode can make that surface area increase according to it.

[0007] Then, DRAM will be obtained if the capacity insulator layer 111 is formed in the front face of the stack electrode 108 using a CVD method as shown in drawing 12 , and the polysilicon comp rate 112 is formed.

[0008] By the way, as HSG-ization of this stack electrode surface was mentioned above, the my great phenomenon of the silicon atom in an electrode (amorphous silicon) front face is used. For this reason, extent of the irregularity formed in an electrode surface changes with the degrees of adhesion of the natural oxidation film to an electrode surface. If it explains in full detail, when the natural oxidation film of an electrode surface is fully removed, as shown in drawing 13 (a), the large hemispherical grain of a path will be in a wrap condition about the whole electrode surface. Moreover, when clearance of the natural oxidation film is inadequate, as shown in drawing 13 (b), a small hemispherical grain will be in the condition that it is scattered in an electrode surface. Moreover, concavo-convex extent changes also by changing the formation conditions of a hemispherical grain.

[0009] When producing DRAM commercially, there must be stored charge capacity of each capacitor within the limits of predetermined. That is, there must be surface area of a stack electrode within the limits of predetermined. However, as mentioned above, extent of the irregularity formed in the front face of a stack electrode can consider various conditions rather than is fixed. For this reason, after forming irregularity in a silicon front face using HSG-Si, it is necessary to evaluate extent of the formed irregularity.

[0010] Conventionally, extent of such irregularity is performed by being performed by the observation which used the electron microscope, or producing a capacitor actually and measuring stored charge capacity.

[0011] Moreover, surface area can also be qualitatively measured by the approach called an adsorption process (for example, gas adsorption BET multipoint method).

[0012] Moreover, a sample front face is made to carry out incidence of the light from the source of the white light, the reflected light from the front face is detected, and there is the approach of acting as the monitor of the surface dry area from decline in a reflection factor. Furthermore, a

sample front face is made to carry out incidence of the monochrome-ized X-ray below by the total reflection critical angle, and the approach of measuring the reinforcement of a secondary X-ray with the detector arranged in the direction of specular reflection is also proposed (JP,4-15933,A).

EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention, by having used 240-500nm light, it is accurate and there are not easy and a thing which has an adverse effect on the property as a device of a sample by the thing which can act as the monitor of the irregularity of the front face of the amorphous silicon film, and for which light is used in this way again, either.
[0047] Moreover, by including the light source and a detecting element in semiconductor fabrication machines and equipment, in situ observation is possible, the processing time is shortened, and improvement in a throughput can be aimed at.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, the observable range of the approach using an electron microscope is narrow, and it has the trouble that the semi-conductor wafer which is a sample is completely unobservable. Moreover, generally the electron microscope which can be observed without dividing a semi-conductor wafer into an intercept is an object for length measurement, and the resolution is about 300nm and has the trouble that a hemispherical grain with a diameter of about 50nm cannot be observed.
[0014] Moreover, although the approach of forming a capacitor actually has the description that the dependability of the measurement result is high, even if it is the easiest process, it makes a capacity insulator layer and an up electrode deposit, must perform patternizing of an up electrode and the outgoing line for measurement, and has the trouble of taking time amount and time and effort too much.
[0015] Moreover, if the approach using an adsorption process considers the effect of gas made to adsorb, application for a actual DRAM product is difficult.
[0016] Furthermore, by the approach of measuring a reflection factor using the white light, in order that an amorphous silicon may penetrate visible region light, it is reflected by the interface of an amorphous silicon and the film under it, and interferes with the reflected light in the front face of an amorphous silicon. Moreover, the light reflected by the interface of an amorphous silicon and the film under it changes depending on the optical property of the lower film. Therefore, this approach has the trouble of being scarce in dependability, in order to act as the monitor of the irregularity formed in the front face of a stack electrode.
[0017] Furthermore, the approach using an X-ray excites the electron inside a sample, makes the channel part of a carrying-out [the capacitor] transistor there to be not only a trouble that the path of the measurement spot cannot be made not much small, but generate a new electronic-electron hole pair, and has the trouble of worsening the property as a device.
[0018] Though it is easy, it is reliable, and this invention aims at offering the surface monitor approach of a thin film of not having an adverse effect on the property as a device of a sample.

MEANS

[Means for Solving the Problem] According to this invention, light is irradiated on the front face of the amorphous silicon film with which a grain was formed in the front face, and the surface monitor approach characterized by using light with a wavelength of 240-500nm as said light is acquired in the surface monitor approach which measures the optical reinforcement of the reflected light and observes the irregularity of said front face.

[0020] Moreover, the surface area of the amorphous silicon film which was beforehand formed in the predetermined field according to this invention and with which a grain was formed in the front face, Ask said amorphous silicon film front face for relation with the reinforcement of the reflected light when irradiating light with a wavelength of 240-500nm, and light with a wavelength of 240-500nm is irradiated on said amorphous silicon film front face. The reinforcement of the reflected light is measured and the surface area measuring method characterized by asking for the surface area of said amorphous silicon film based on the relation of said surface area and said reflected light is acquired.

[0021] Furthermore, the sample maintenance means which was arranged in the chamber as for which the interior is made to a vacuum, and said chamber according to this invention, In the manufacturing installation of a semiconductor device which has a gas installation means to introduce the material gas for forming a grain in the front face of the heater which heats the sample held at said sample maintenance means, and the amorphous silicon film formed in the predetermined field of said sample The light source which irradiates light with a wavelength of 240-500nm towards said sample, and the photodetection section which detects the reinforcement of the reflected light from said sample are prepared. The manufacturing installation of the semiconductor device characterized by the ability to carry out the in situ observation of the front face of said amorphous silicon film in which said grain was formed is obtained. In the manufacture approach of the semiconductor device which forms a grain in the front face of the amorphous silicon film which serves as an electrode for forming a capacitor further again according to this invention While forming said grain in the front face of said amorphous silicon film When light with a wavelength of 240-500nm is irradiated on the front face of said amorphous silicon film, the reinforcement of the reflected light is measured and the reinforcement of said reflected light is less than a predetermined value, the manufacture approach of the semiconductor device characterized by ending formation of said grain is acquired. Moreover, according to this invention, it sets to the manufacture approach of the

semiconductor device which forms the amorphous silicon film in a predetermined field, and forms a grain in the front face of said amorphous silicon film. While forming a grain in the front face of said amorphous silicon film The manufacture approach of the semiconductor device characterized by including the process which irradiates light with a wavelength of 240-500nm on the front face of said amorphous silicon film containing said grain, measures the reinforcement of the reflected light, and observes the irregularity of the front face concerned is acquired.

EXAMPLE

[Example] Hereafter, the example of this invention is explained with reference to a drawing. The measuring device used for drawing 1 by the 1st example of this invention is shown. The measuring device shown in drawing 1 has the sample base 12 in which a sample 11 is laid, the light source section 13, the optical-axis system part 14 which irradiates the light from the light source section 13 on the front face of a sample 11, and condenses the reflected light, the spectroscope 15 which carries out the spectrum of the reflected light condensed by part for the optical-axis diameter 14, and the data-processing section 16 connected to the spectroscope 15.

[0023] The light source section 13 can change the wavelength of the light which carries out outgoing radiation. That is, this measuring device can measure the reflection factor of the sample according to the wavelength of light. Moreover, the data-processing section 16 measures beforehand reflected light reinforcement, such as a standard silicon substrate which processed mirror polishing etc. on the front face, and integrates with and displays the reflected light reinforcement of a sample by making the value into 100% of reflection factors.

[0024] The reflection factor (a broken line shows) of the front face of an amorphous silicon to light with a wavelength of 240-750nm and the reflection factor (a continuous line shows) of the light of the front face in which HSG-Si was formed on the amorphous silicon were measured using this equipment. The result is shown in drawing 2 . In any case, it decreases from drawing 2 almost in monotone [a reflection factor] with the increment in wavelength to the wavelength of 550nm a clear passage. Moreover, the reflection factor of the front face in which HSG-Si was formed becomes quite smaller than the reflection factor of the front face of the amorphous silicon which is not formed. Moreover, if wavelength exceeds 600nm, in any case, a reflection factor will be changed sharply. This is considered to be for the light reflected by the interface of an amorphous silicon and the film under it to interfere in the reflected light in a front face. When the thickness of the amorphous silicon film is thick, or when degree of crystallinity is high,

fluctuation of this reflection factor will begin from near the wavelength of 550nm, if a refractive index becomes low. In addition, since the optical absorption multiplier of silicon increases [wavelength] dramatically to light 550nm or less, most light which invaded in silicon is absorbed. therefore, about 100% of the reflected light measured when wavelength uses light 550nm or less is the reflected light from the outermost surface -- it thinks.

[0025] It turns out that the concavo-convex condition of the front face of an amorphous silicon can be known, without being influenced by the above-mentioned result of the condition of the membraneous quality of an amorphous silicon, thickness, and the film under an amorphous silicon, if light 500nm or less is used.

[0026] Next, the semiconductor device (DRAM) was produced actually, HSG-Si was formed in the front face of a stack electrode, and the reflection factor was measured with the measuring device (wavelength of 240-500nm) of this example. Moreover, after that, the capacitor was produced, stored charge capacity was measured and it considered as instead of [of measurement of the surface area of a stack electrode]. The result is shown in drawing 3 (a) and (b).

[0027] Drawing 3 (a) is the front face of a stack electrode when forming HSG-Si Si2H6 The relation between the time amount exposed to gas, and a surface reflection factor and stored charge capacity is shown (however, it shall expose to N2 for 10 minutes after this). Moreover, drawing 3 (b) is Si two H6 about the front face of a stack electrode. It is the front face after exposing to gas (for 3 minutes) N2 The relation between the exposed time amount, and a surface reflection factor and stored charge capacity is shown.

[0028] Relation is between a surface reflection factor and stored charge capacity (surface area) clearly, and the one of surface area where a surface reflection factor is lower is large so that drawing 3 (a) and (b) may show. Moreover, drawing 3 (a) is Si two H6. If time amount exposed to gas is lengthened too much, it is shown that surface area decreases. The rate of this that increase and the light from the light source 41 are scattered by the grain in the consistency as the grain formed in an electrode surface shows drawing 4 (a), (b), and (c) with time amount progress increases, and further, the grains which adjoin as shown in drawing 4 (d) if formation of a grain is continued join, and it thinks for the reflected light to come to carry out incidence to a detector 42. Moreover, drawing 3 (b) is N2. It is shown that it is meaningless even if it lengthens time amount to expose to some extent more.

[0029] if the equipment of this example is used and the reflection factor of the front face is

measured, when forming HSG-Si and making the surface area of a stack electrode increase from the above-mentioned thing -- which -- about -- it can presume whether surface area increased. For example, when it is going to double [more than] the surface area of a stack electrode, a surface reflection factor should just be 20% or less. When a reflection factor exceeds 20%, it turns out that it is necessary to deal with forming HSG-Si again etc. Thus, if the measuring device of this example is used, it is in the middle of production of DRAM, and after forming HSG-Si, the stored charge capacity of a capacitor can be presumed. That is, if the measured reflection factor is below a predetermined value, the semiconductor device (DRAM) produced after that will have a desired capacitor stored charge capacity.

[0030] In addition, although wavelength of the light to be used was set to 240-500nm in the above-mentioned example, you may make it use the light of the single wavelength of this range, for example, about 488nm Ar laser light.

[0031] Moreover, although incidence of the light is vertically carried out to a sample and the vertical reflected light was measured in the measuring device of this example, it is not restricted to this and the detection location of the reflected light should just be a location which detects the specular reflection component of incident light.

[0032] Furthermore, although the measuring device of this example was used for the monitor of HSG-Si, the surface monitor of other matter is also possible.

[0033] Next, the 2nd example of this invention is explained. Although [the 1st example] it is in the middle of production of DRAM and the reflection factor of a stack electrode (HSG-Si) front face is measured, in this example, a reflection factor is measured as follows.

[0034] First, after forming HSG-Si in the front face of a stack electrode as usual (refer to drawing 8 (d)), a wafer is dipped into a rare HF solution and the natural oxidation film of the electrode surface which turned HSG is removed. An electrode surface is immediately exposed to ammonia after that, and 850-degree C lamp heating is performed for 1 minute. Then, as shown in drawing 5 , the about 2nm silicon nitride 51 is formed in the front face of a stack electrode. Then, a reflection factor is measured like the 1st example using light with a wavelength of 240-500nm. At this time, it was checked that the very thin silicon nitride 51 10nm or less hardly affects measurement of a reflection factor. Therefore, if a reflection factor is 20% or less, the surface area of an electrode will be considered to be more than twice, and will not interfere. That is, the stored charge capacity of the capacitor produced after that can be presumed by measuring the

reflection factor of the light of a stack electrode surface.

[0035] then, a capacity insulator layer -- and if polysilicon comp rate formation is carried out, the same semiconductor device will be obtained as substantially as the former.

[0036] The natural oxidation film of the front face of the stack electrode which turned HSG is removed, and by having formed the silicon nitride after that, immediately after performing HSG-ization of a stack electrode, it is not necessary to measure a reflection factor at this example. In addition, although there was decline in about 5% of reflection factor under the effect of the natural oxidation film when it was left at a room temperature for one week after performing HSG-ization of a stack electrode, in the case of this example, lowering was hardly seen.

[0037] Next, the 3rd example of this invention is explained. The reflection factor is measured in this example, building a measuring device into the HSG-Si formation equipment of single wafer processing, and forming HSG-Si.

[0038] The equipment used for this example has the sample base 64 established in the chamber 63 which has the gas installation port 61 and the evacuation port 62, and the chamber 63, a heater 65, the light source 66 which carries out outgoing radiation of the light with a wavelength of 365nm, and a detector 67, as shown in drawing 6 .

[0039] When forming HSG-Si with this equipment, the sample 68 which has a pure amorphous silicon front face (stack electrode) is first introduced in the chamber 63 held at the vacuum. And a sample 68 is heated at a heater 65. The temperature is made into 580 degrees C. Next, the gas installation port 61 to Si two H6 Gas is introduced for 10 minutes. It adjusts so that the pressure in a chamber 63 may serve as 1mtorr at this time. Next, Si two H6 Installation of gas is suspended and it is Si two H6 in a chamber 63. If gas is exhausted from the evacuation port 62 and the temperature of a sample is held, annealing of the sample will be carried out in a vacuum, and HSG-Si will be formed in a front face.

[0040] In this example, in situ observation while forming HSG-Si is possible. This observation can also be performed from the time of the sample installation to a chamber 73, and you may make it start at a suitable stage (for example, when starting annealing). Observation irradiates the light from the light source 66 at a sample 68, and is performed by a detector detecting the reflected light. An example of observation is shown in drawing 7 . Setting to drawing 7 , for Period A, Period B is Si two H6 about sample installation and a warm up period. Period C shows an annealing treatment period for an introductory period.

[0041] If an annealing process starts, the reinforcement of the reflected light will decrease rapidly and will be saturated after that, so that clearly from drawing 7 . Each [of C1, C2, C3, and C4 of drawing] four samples which end annealing treatment at the event were produced, and the front face was observed with the electron microscope. The result is shown in drawing 8 (a), (b), (c), and (d). Here, drawing 8 (a), (b), (c), and (d) correspond to the sample which ended annealing by C1, C2, C3, and C4 of drawing 7 , respectively.

[0042] As shown in drawing 8 (a), (b), and (c), the grain size of HSG-Si accompanying the strength reduction (C1 ->C2 ->C3) of the reflected light has observed buildup. Moreover, as shown in drawing 8 (c) and (d), change of the grain size of HSG-Si was not seen in the field (C3 ->C4) in which the reinforcement of the reflected light is saturated. Moreover, the capacitor was produced using these samples and the stored charge capacity was measured. The result is shown in drawing 9 . As shown in drawing 9 , rapid buildup of stored charge capacity is seen in the field in which the reinforcement of the reflected light decreases (C1 ->C2 ->C3), and stored charge capacity is also saturated with the field (C3 ->C4) in which the reinforcement of the reflected light is saturated.

[0043] Thus, in this example, forming HSG-Si, in situ observation is possible and the stored charge capacity when producing a capacitor from the measured reflection factor can be presumed.

[0044] In addition, although light with a wavelength of 365nm was used in the above-mentioned example, as long as it is within the limits of 240-500nm, the light of other wavelength is sufficient. Moreover, not the light of single wavelength but the light of the wavelength range which has a certain range may be used.

[0045] Moreover, although the above-mentioned example explained the example which built the measuring device into single-wafer-processing equipment, as shown in drawing 10 , it is also incorporable into the batch-processing equipment of hot wall structure. Here, in the equipment of drawing 10 , the same number is given to drawing 6 and a functional target at the same thing.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the schematic diagram of the measuring device used for the 1st example of this invention.

[Drawing 2] It is the graph which shows relation with the reflection factor of the front face of a next amorphous silicon before forming a hemispherical grain, the wavelength of light measured

using the equipment of drawing 1 , and.

[Drawing 3] It is the graph which shows the relation of the processing time of each process and the reflection factor which were measured using the equipment of drawing 1 , and the relation between the processing time of each process, and the stored charge capacity of the capacitor produced after that, and (a) is Si two H6. (b) is N2 when changing the time amount to expose. The case where the heat treatment time amount under an ambient atmosphere is changed is shown.

[Drawing 4] It is a conceptual diagram for explaining the relation between the formation condition of a hemispherical grain, and that of a reflection factor, and (d) shows the case where the grains which, as for (b), (c) shows the case where a grain is high density to, respectively when a grain is a low consistency, and a grain is semi-gross density, and (a) adjoins join.

[Drawing 5] It is the cross section of DRAM in preparation [for explaining the 2nd example of this invention].

[Drawing 6] It is used for the 3rd example of this invention, and is the schematic diagram of semiconductor fabrication machines and equipment.

[Drawing 7] It is the graph which shows the relation of the grain formation time amount and the surface reflection factor which were measured using the equipment of drawing 6 .

[Drawing 8] (a), (b), (c), and (d) are the microphotographies of the particulate structure of the grain formed in the front face of the electrode at the event of C1, C2, C3, and C4 of drawing 7 , respectively.

[Drawing 9] It is the graph which shows the relation between annealing time amount and stored charge capacity.

[Drawing 10] It is the schematic diagram of other semiconductor fabrication machines and equipment which can be used for the 3rd example of this invention.

[Drawing 11] It is process drawing for explaining the production process of the conventional DRAM.

[Drawing 12] It is the cross section showing the structure of DRAM.

[Drawing 13] It is the microphotography of the particulate structure of the grain formed on the surface of the electrode, and when a grain is formed after (a) fully removed the natural oxidation film of an electrode surface, it shows the case where a grain is formed without (b) fully removing the natural oxidation film of an electrode surface.

[Description of Notations]

11 Sample

12 Sample Base

13 Light Source Section

14 Optical-Axis System Part

15 Spectroscope

16 Data-Processing Section

41 Light Source

42 Detector

51 Silicon Nitride

61 Gas Installation Port

62 Evacuation Port

63 Chamber

64 Sample Base

65 Heater

66 Light Source

67 Detector

68 Sample

101 High Concentration Impurity Diffused Layer

102 Isolation Insulator Layer

103 Gate Electrode

104 P Type Silicon Substrate

105 Interlayer Insulation Film

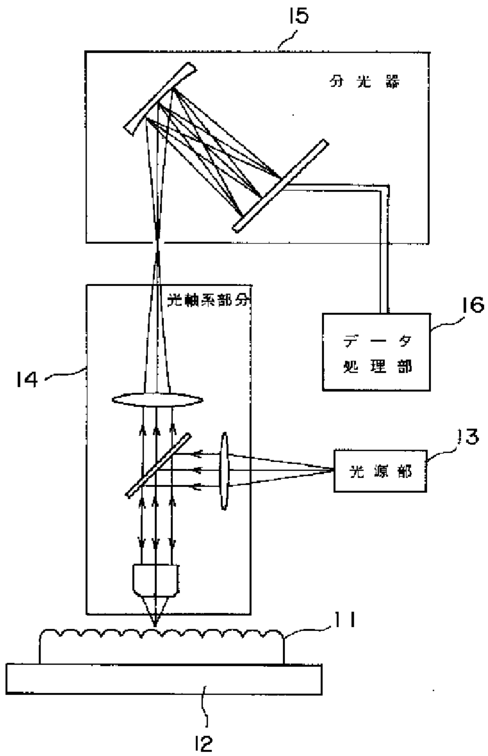
106 Contact Hole

107 Amorphous Silicon Film

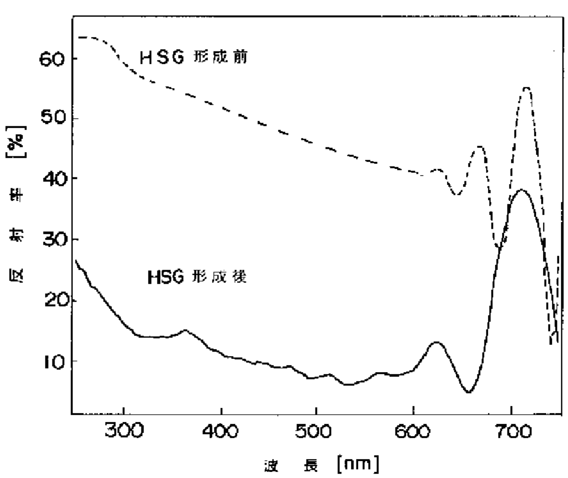
108 Stack Electrode

109 Hemispherical Grain (HSG-Si)

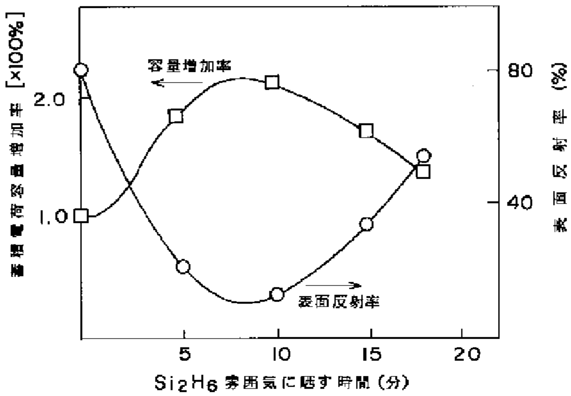
Drawing 1



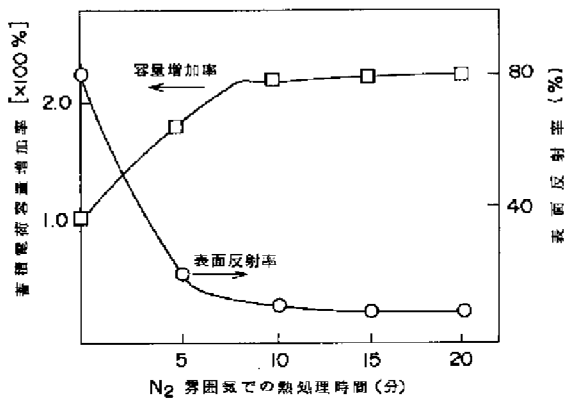
Drawing 2



Drawing 3

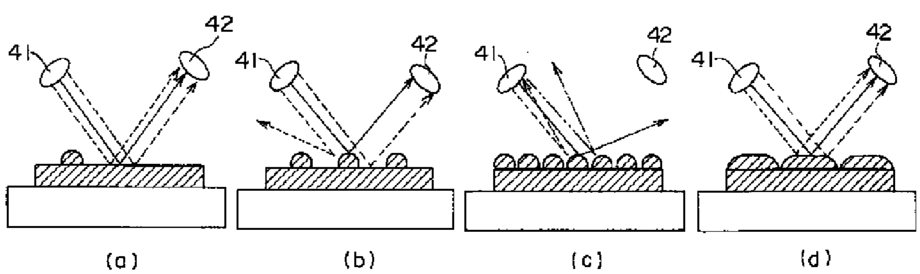


(a)

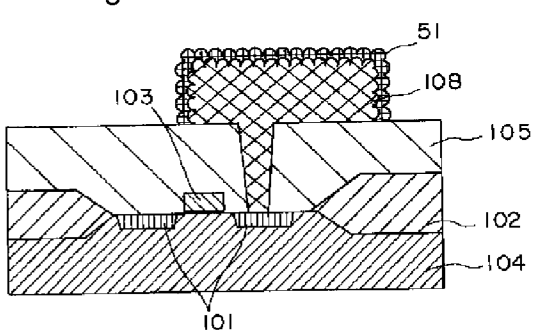


(b)

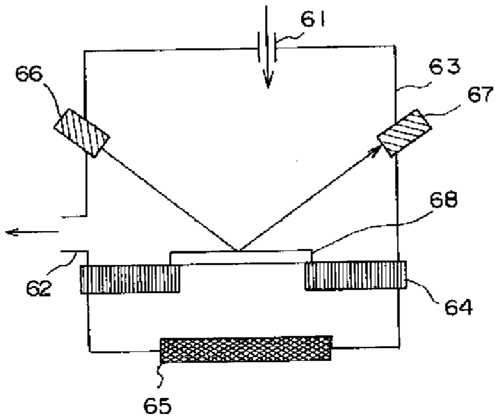
Drawing 4



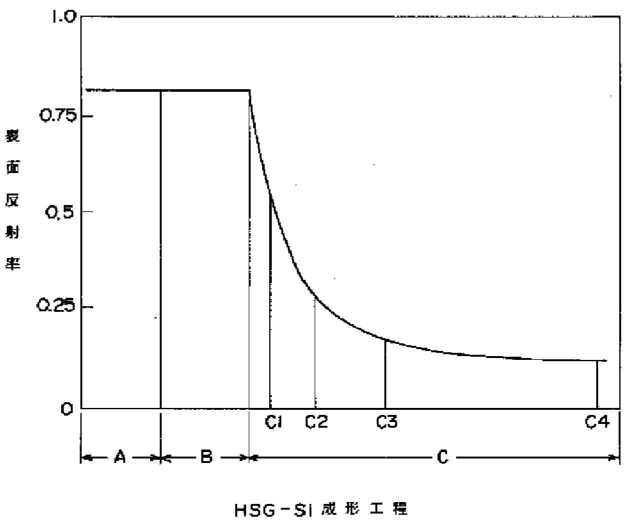
Drawing 5



Drawing 6

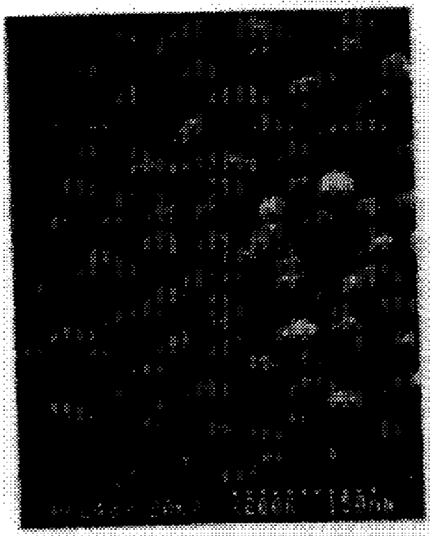


Drawing 7



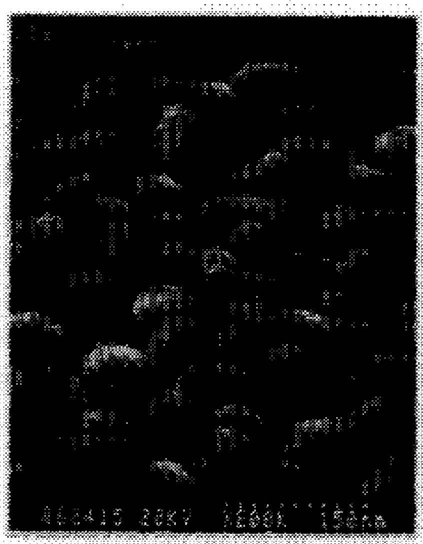
Drawing 8

図面代用写真



(a)

(b)

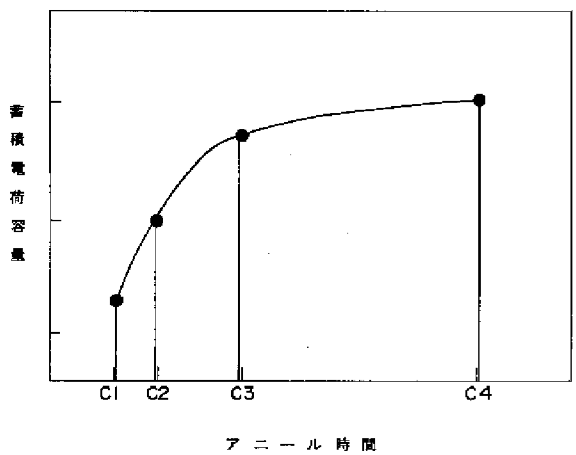


(c)

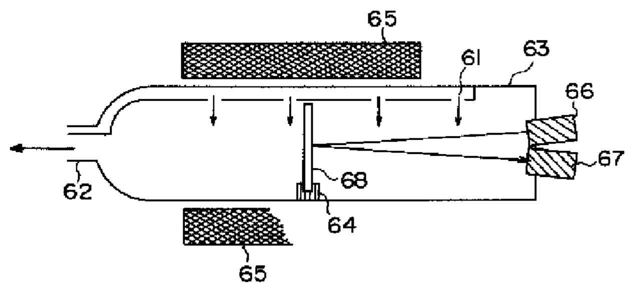
(d)

写 真

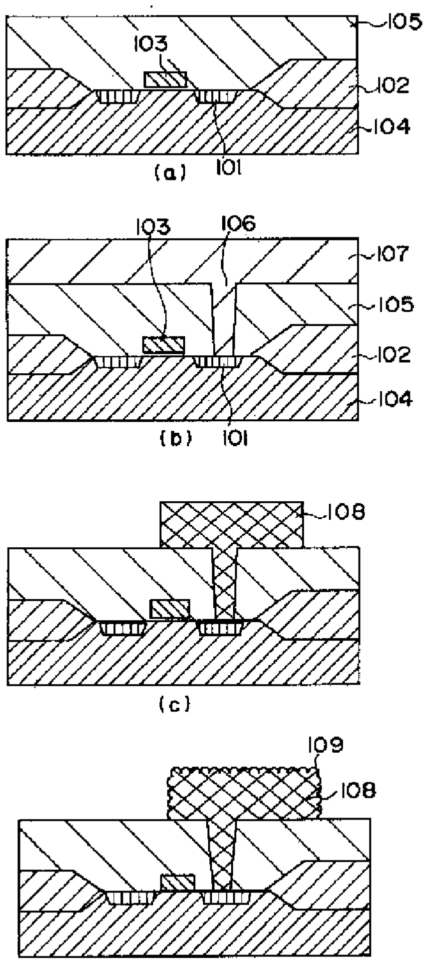
Drawing 9



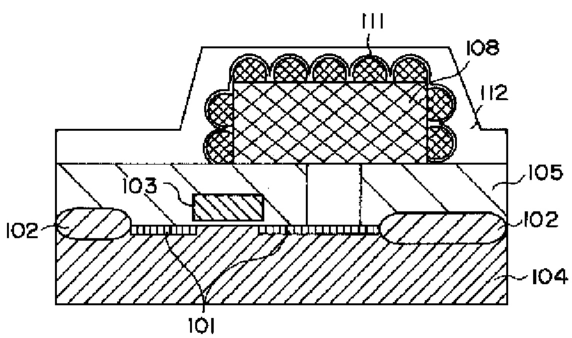
Drawing 10



Drawing 11

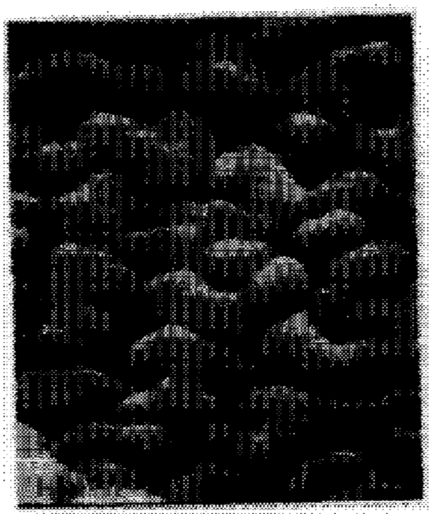


Drawings 12

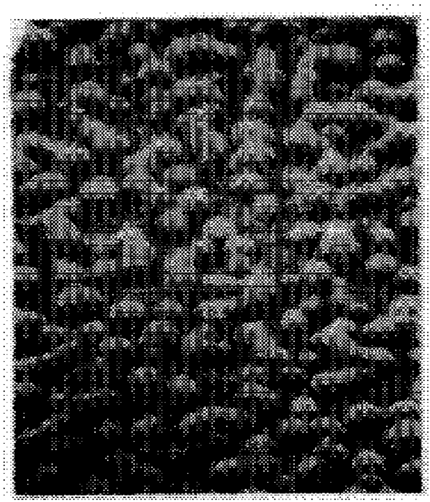


Drawing 13

図面代用写真



（a）



（b）

写　　　真

PATENT ABSTRACTS OF JAPAN

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G01B 11/30
H01L 21/66
H01L 27/108
H01L 21/8242

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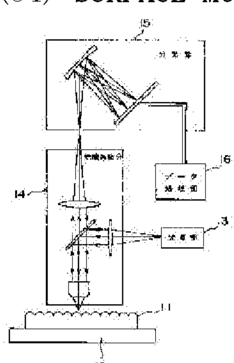
AISOU FUMINORI

(54) SURFACE MONITORING METHOD



(57)Abstract:
PURPOSE: To prevent ill effects from exerting on sample characteristics and monitor a thin film surface by irradiating a light of a special wavelength on the surface of a semiconductor thin film and measuring the reflection light intensity so as to observe the surface recession and projection.
CONSTITUTION: A light source part 13 can change the wavelength of an emitting light, its light irradiates the surface of a sample 11 and the

reflection light is collected by an optical axis system part 14, it is separated by a spectroscope 15, and obtained data is supplied to a data processing part 16. The processing part 16 measures the reflection light intensity such as standard silicon substrate, etc., beforehand, its reflection rate is assumed to be 100%, and the reflection light intensity of a sample is integrated so as to be displayed. The wavelength of the light of the light source part 13 is set to approximately 240-500nm so that recessed and projecting states of the surface of amorphous silicon are obtained without affected by film quality and the thickness of the amorphous silicon, and the states of the film beneath. And it does not exert ill effects on the characteristics as a device of a sample.

LEGAL STATUS

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[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	2638554
[Date of registration]	25.04.1997
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

CLAIMS

[Claim(s)]
[Claim 1] The surface monitor approach characterized by using light with a wavelength of 240-500nm as said light in the surface monitor approach which irradiates light on the front face of a semi-conductor thin film, measures the optical reinforcement of the reflected light, and observes the irregularity of said front face.
[Claim 2] The surface monitor approach of claim 1 characterized by said semi-conductor thin film being a silicon thin film.
[Claim 3] The surface monitor approach of claim 1 characterized by said semi-conductor thin film being the hemispherical grain formed in an amorphous silicon and its front face.
[Claim 4] The surface monitor approach of claims 2 or 3 characterized by forming the silicon nitride of 10nm or less of thickness in the front face of said semi-conductor thin film.
[Claim 5] The surface area measuring method characterized by asking for the relation between the surface area of the semi-conductor thin film formed in the predetermined field, and the reinforcement of the reflected light when irradiating light with a wavelength of 240-500nm on said semi-conductor thin film front face beforehand, irradiating light with a wavelength of 240-500nm on said semi-conductor thin film front face, measuring the reinforcement of the reflected light, and asking for the surface area of said semi-conductor thin film based on the relation of said surface area and said reflected light.
[Claim 6] The chamber which can carry out evacuation of the interior, and the sample maintenance means arranged in this chamber, In the semi-conductor thin film deposition system which has the heater which heats the sample held at this sample maintenance means, and a gas installation means to introduce the material gas for forming a semi-conductor thin film in the front face of said sample Semi-conductor formation equipment characterized by preparing the light source which irradiates light with a wavelength of 240-500nm towards said sample, and the photodetection section which detects the reinforcement of the reflected light from said sample, and being able to carry out the in situ observation of the front face of said semi-conductor thin film.
[Claim 7] Semi-conductor formation equipment characterized by said semi-conductor thin film being a silicon thin film.
[Claim 8] The manufacture approach of DRAM characterized by forming said capacitor when light with a wavelength of 240-500nm is irradiated on the front face of said stack electrode, the reinforcement of the reflected

light is measured and the reinforcement of said reflected light is less than a predetermined value in the manufacture approach of DRAM which forms a hemispherical grain in the front face of the stack electrode for forming a capacitor after producing said hemispherical grain.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to the monitor approach which acts as the monitor of the front face of the silicone film formed when producing a semiconductor integrated circuit about the surface monitor approach of a thin film.
[0002]
[Description of the Prior Art] In recent years, high integration of a semiconductor integrated circuit is tried briskly, and is not an exception about DRAM (Dynamic Random Access Memory), either. In order to integrate DRAM highly, the number of the capacitors per unit area must be increased, and the formation area inevitably given to one capacitor becomes small. If the formation area of a capacitor contracts, the stored charge capacity of a capacitor will decrease and various problems, such as destruction (alpha-rays soft error) of the data based on alpha rays, will arise. So, recently, a device is added to the structure of a capacitor and the attempt which is made to increase an electrode surface product and secures a required stored charge capacity has accomplished.
[0003] For example, H.Watanabe etc. is "A New stacked capacitor structure using hemispherical-grain poly-silicon electrode". In 22 nd Conference on Solid Device and Materials and p.873 (1990), a hemispherical grain (HSG-Si) was formed in the electrode surface of a

capacitor, and the approach to which an electrode surface product is made to increase is proposed. This approach is the approach of forming irregularity in a silicon front face using the my great phenomenon of the silicon atom by heat in a pure silicon front face. Hereafter, this approach is explained with reference to drawing 11 about the case where it uses for manufacture of DRAM (stack mold memory cell).

[0004] First, as shown in drawing 11 (a), an interlayer insulation film 105 is formed on the high concentration impurity diffused layer 101, the isolation insulator layer 102, and the P type silicon substrate 104 in which the gate electrode 103 was formed. And the contact hole which reaches one high grade impurity diffused layer 101 is formed in an interlayer insulation film 105 using a lithography technique and an etching technique.

[0005] Then, as shown in drawing 11 (b), the amorphous silicon film 107 which doped Lynn is formed in a contact hole 106 and on an interlayer insulation film 105 using a reduced pressure CDV technique. And again, using a lithography technique and an etching technique, the amorphous silicon film 107 of the predetermined range is etched, and as shown in drawing 11 (c), the stack electrode 108 is formed.

[0006] Next, HSG-ization of a stack electrode surface is performed. the substrate 104 with which this formed the stack electrode 108 -- the bottom of about 580 degrees C and reduced pressure of about 1 mtorr -- placing -- Si two H6 after exposing to gas about 10 minutes -- succeedingly -- isothermal - isotonic -- ** and N2 It realizes by exposing to an ambient atmosphere about 30 minutes. As shown in drawing 11 (d), it is irregularity-ized by this process, namely, the hemispherical grain (HSG-Si) 109 is formed of it, and the front face of a stack electrode can make that surface area increase according to it.

[0007] Then, DRAM will be obtained if the capacity insulator layer 111 is formed in the front face of the stack electrode 108 using a CVD method as shown in drawing 12 , and the polysilicon comp rate 112 is formed.

[0008] By the way, as HSG-ization of this stack electrode surface was mentioned above, the my great phenomenon of the silicon atom in an electrode (amorphous silicon) front face is used. For this reason, extent of the irregularity formed in an electrode surface changes with the degrees of adhesion of the natural oxidation film to an electrode surface. If it explains in full detail, when the natural oxidation film of an electrode surface is fully removed, as shown in drawing 13 (a), the large hemispherical grain of a path will be in a wrap condition about the whole electrode surface. Moreover, when clearance of the

natural oxidation film is inadequate, as shown in drawing 13 (b), a small hemispherical grain will be in the condition that it is scattered in an electrode surface. Moreover, concavo-convex extent changes also by changing the formation conditions of a hemispherical grain.
[0009] When producing DRAM commercially, there must be stored charge capacity of each capacitor within the limits of predetermined. That is, there must be surface area of a stack electrode within the limits of predetermined. However, as mentioned above, extent of the irregularity formed in the front face of a stack electrode can consider various conditions rather than is fixed. For this reason, after forming irregularity in a silicon front face using HSG-Si, it is necessary to evaluate extent of the formed irregularity.
[0010] Conventionally, extent of such irregularity is performed by being performed by the observation which used the electron microscope, or producing a capacitor actually and measuring stored charge capacity.
[0011] Moreover, surface area can also be qualitatively measured by the approach called an adsorption process (for example, gas adsorption BET multipoint method).
[0012] Moreover, a sample front face is made to carry out incidence of the light from the source of the white light, the reflected light from the front face is detected, and there is the approach of acting as the monitor of the surface dry area from decline in a reflection factor. Furthermore, a sample front face is made to carry out incidence of the monochrome-ized X-ray below by the total reflection critical angle, and the approach of measuring the reinforcement of a secondary X-ray with the detector arranged in the direction of specular reflection is also proposed (JP,4-15933,A).
[0013]
[Problem(s) to be Solved by the Invention] However, the observable range of the approach using an electron microscope is narrow, and it has the trouble that the semi-conductor wafer which is a sample is completely unobservable. Moreover, generally the electron microscope which can be observed without dividing a semi-conductor wafer into an intercept is an object for length measurement, and the resolution is about 300nm and has the trouble that a hemispherical grain with a diameter of about 50nm cannot be observed.
[0014] Moreover, although the approach of forming a capacitor actually has the description that the dependability of the measurement result is high, even if it is the easiest process, it makes a capacity insulator layer and an up electrode deposit, must perform patternizing of an up electrode and the outgoing line for measurement, and has the trouble of

taking time amount and time and effort too much.
[0015] Moreover, if the approach using an adsorption process considers the effect of gas made to adsorb, application for a actual DRAM product is difficult.
[0016] Furthermore, by the approach of measuring a reflection factor using the white light, in order that an amorphous silicon may penetrate visible region light, it is reflected by the interface of an amorphous silicon and the film under it, and interferes with the reflected light in the front face of an amorphous silicon. Moreover, the light reflected by the interface of an amorphous silicon and the film under it changes depending on the optical property of the lower film. Therefore, this approach has the trouble of being scarce in dependability, in order to act as the monitor of the irregularity formed in the front face of a stack electrode.
[0017] Furthermore, the approach using an X-ray excites the electron inside a sample, makes the channel part of a carrying-out [the capacitor] transistor there to be not only a trouble that the path of the measurement spot cannot be made not much small, but generate a new electronic-electron hole pair, and has the trouble of worsening the property as a device.
[0018] Though it is easy, it is reliable, and this invention aims at offering the surface monitor approach of a thin film of not having an adverse effect on the property as a device of a sample.
[0019]
[Means for Solving the Problem] According to this invention, light is irradiated on the front face of a semi-conductor thin film, and the surface monitor approach characterized by using light with a wavelength of 240-500nm as said light is acquired in the surface monitor approach which measures the optical reinforcement of the reflected light and observes the irregularity of said front face.
[0020] Moreover, the surface area of the semi-conductor thin film which was beforehand formed in the predetermined field according to this invention, Ask said semi-conductor thin film front face for relation with the reinforcement of the reflected light when irradiating light with a wavelength of 240-500nm, and light with a wavelength of 240-500nm is irradiated on said semi-conductor thin film front face. The reinforcement of the reflected light is measured and the surface area measuring method characterized by asking for the surface area of said semi-conductor thin film based on the relation of said surface area and said reflected light is acquired.
[0021] The chamber which can carry out evacuation of the interior

further again according to this invention, The sample maintenance means arranged in this chamber, and the heater which heats the sample held at this sample maintenance means, In the semi-conductor thin film deposition system which has a gas installation means to introduce the material gas for forming a semi-conductor thin film in the front face of said sample The light source which irradiates light with a wavelength of 240-500nm towards said sample, and the photodetection section which detects the reinforcement of the reflected light from said sample are prepared, and the semi-conductor formation equipment characterized by the ability to carry out the in situ observation of the front face of said semi-conductor thin film is obtained.

[0022]

[Example] Hereafter, the example of this invention is explained with reference to a drawing. The measuring device used for drawing 1 by the 1st example of this invention is shown. The measuring device shown in drawing 1 has the sample base 12 in which a sample 11 is laid, the light source section 13, the optical-axis system part 14 which irradiates the light from the light source section 13 on the front face of a sample 11, and condenses the reflected light, the spectroscope 15 which carries out the spectrum of the reflected light condensed by part for the optical-axis diameter 14, and the data-processing section 16 connected to the spectroscope 15.

[0023] The light source section 13 can change the wavelength of the light which carries out outgoing radiation. That is, this measuring device can measure the reflection factor of the sample according to the wavelength of light. Moreover, the data-processing section 16 measures beforehand reflected light reinforcement, such as a standard silicon substrate which processed mirror polishing etc. on the front face, and integrates with and displays the reflected light reinforcement of a sample by making the value into 100% of reflection factors.

[0024] The reflection factor (a broken line shows) of the front face of an amorphous silicon to light with a wavelength of 240-750nm and the reflection factor (a continuous line shows) of the light of the front face in which HSG-Si was formed on the amorphous silicon were measured using this equipment. The result is shown in drawing 2 . In any case, it decreases from drawing 2 almost in monotone [a reflection factor] with the increment in wavelength to the wavelength of 550nm a clear passage. Moreover, the reflection factor of the front face in which HSG-Si was formed becomes quite smaller than the reflection factor of the front face of the amorphous silicon which is not formed. Moreover, if wavelength exceeds 600nm, in any case, a reflection factor will be

changed sharply. This is considered to be for the light reflected by the interface of an amorphous silicon and the film under it to interfere in the reflected light in a front face. When the thickness of the amorphous silicon film is thick, or when degree of crystallinity is high, fluctuation of this reflection factor will begin from near the wavelength of 550nm, if a refractive index becomes low. In addition, since the optical absorption multiplier of silicon increases [wavelength] dramatically to light 550nm or less, most light which invaded in silicon is absorbed. therefore, about 100% of the reflected light measured when wavelength uses light 550nm or less is the reflected light from the outermost surface -- it thinks.

[0025] It turns out that the concavo-convex condition of the front face of an amorphous silicon can be known, without being influenced by the above-mentioned result of the condition of the membraneous quality of an amorphous silicon, thickness, and the film under an amorphous silicon, if light 500nm or less is used.

[0026] Next, the semiconductor device (DRAM) was produced actually, HSG-Si was formed in the front face of a stack electrode, and the reflection factor was measured with the measuring device (wavelength of 240-500nm) of this example. Moreover, after that, the capacitor was produced, stored charge capacity was measured and it considered as instead of [of measurement of the surface area of a stack electrode]. The result is shown in drawing 3 (a) and (b).

[0027] Drawing 3 (a) is the front face of a stack electrode when forming HSG-Si Si2H6 The relation between the time amount exposed to gas, and a surface reflection factor and stored charge capacity is shown (however, it shall expose to N2 for 10 minutes after this). Moreover, drawing 3 (b) is Si two H6 about the front face of a stack electrode. It is the front face after exposing to gas (for 3 minutes) N2 The relation between the exposed time amount, and a surface reflection factor and stored charge capacity is shown.

[0028] Relation is between a surface reflection factor and stored charge capacity (surface area) clearly, and the one of surface area where a surface reflection factor is lower is large so that drawing 3 (a) and (b) may show. Moreover, drawing 3 (a) is Si two H6. If time amount exposed to gas is lengthened too much, it is shown that surface area decreases. The rate of this that increase and the light from the light source 41 are scattered by the grain in the consistency as the grain formed in an electrode surface shows drawing 4 (a), (b), and (c) with time amount progress increases, and further, the grains which adjoin as shown in drawing 4 (d) if formation of a grain is continued join, and it

thinks for the reflected light to come to carry out incidence to a detector 42. Moreover, drawing 3 (b) is N2. It is shown that it is meaningless even if it lengthens time amount to expose to some extent more.

[0029] if the equipment of this example is used and the reflection factor of the front face is measured, when forming HSG-Si and making the surface area of a stack electrode increase from the above-mentioned thing -- which -- about -- it can presume whether surface area increased. For example, when it is going to double [more than] the surface area of a stack electrode, a surface reflection factor should just be 20% or less. When a reflection factor exceeds 20%, it turns out that it is necessary to deal with forming HSG-Si again etc. Thus, if the measuring device of this example is used, it is in the middle of production of DRAM, and after forming HSG-Si, the stored charge capacity of a capacitor can be presumed. That is, if the measured reflection factor is below a predetermined value, the semiconductor device (DRAM) produced after that will have a desired capacitor stored charge capacity.

[0030] In addition, although wavelength of the light to be used was set to 240-500nm in the above-mentioned example, you may make it use the light of the single wavelength of this range, for example, about 488nm Ar laser light.

[0031] Moreover, although incidence of the light is vertically carried out to a sample and the vertical reflected light was measured in the measuring device of this example, it is not restricted to this and the detection location of the reflected light should just be a location which detects the specular reflection component of incident light.

[0032] Furthermore, although the measuring device of this example was used for the monitor of HSG-Si, the surface monitor of other matter is also possible.

[0033] Next, the 2nd example of this invention is explained. Although [the 1st example] it is in the middle of production of DRAM and the reflection factor of a stack electrode (HSG-Si) front face is measured, in this example, a reflection factor is measured as follows.

[0034] First, after forming HSG-Si in the front face of a stack electrode as usual (refer to drawing 8 (d)), a wafer is dipped into a rare HF solution and the natural oxidation film of the electrode surface which turned HSG is removed. An electrode surface is immediately exposed to ammonia after that, and 850-degree C lamp heating is performed for 1 minute. Then, as shown in drawing 5 , the about 2nm silicon nitride 51 is formed in the front face of a stack electrode. Then, a reflection factor is measured like the 1st example using light with a wavelength of

240-500nm. At this time, it was checked that the very thin silicon nitride 51 10nm or less hardly affects measurement of a reflection factor. Therefore, if a reflection factor is 20% or less, the surface area of an electrode will be considered to be more than twice, and will not interfere. That is, the stored charge capacity of the capacitor produced after that can be presumed by measuring the reflection factor of the light of a stack electrode surface.

[0035] then, a capacity insulator layer -- and if polysilicon comp rate formation is carried out, the same semiconductor device will be obtained as substantially as the former.

[0036] The natural oxidation film of the front face of the stack electrode which turned HSG is removed, and by having formed the silicon nitride after that, immediately after performing HSG-ization of a stack electrode, it is not necessary to measure a reflection factor at this example. In addition, although there was decline in about 5% of reflection factor under the effect of the natural oxidation film when it was left at a room temperature for one week after performing HSG-ization of a stack electrode, in the case of this example, lowering was hardly seen.

[0037] Next, the 3rd example of this invention is explained. The reflection factor is measured in this example, building a measuring device into the HSG-Si formation equipment of single wafer processing, and forming HSG-Si.

[0038] The equipment used for this example has the sample base 64 established in the chamber 63 which has the gas installation port 61 and the evacuation port 62, and the chamber 63, a heater 65, the light source 66 which carries out outgoing radiation of the light with a wavelength of 365nm, and a detector 67, as shown in drawing 6 .

[0039] When forming HSG-Si with this equipment, the sample 68 which has a pure amorphous silicon front face (stack electrode) is first introduced in the chamber 63 held at the vacuum. And a sample 68 is heated at a heater 65. The temperature is made into 580 degrees C. Next, the gas installation port 61 to Si two H6 Gas is introduced for 10 minutes. It adjusts so that the pressure in a chamber 63 may serve as 1mtorr at this time. Next, Si two H6 Installation of gas is suspended and it is Si two H6 in a chamber 63. If gas is exhausted from the evacuation port 62 and the temperature of a sample is held, annealing of the sample will be carried out in a vacuum, and HSG-Si will be formed in a front face.

[0040] In this example, in situ observation while forming HSG-Si is possible. This observation can also be performed from the time of the

sample installation to a chamber 73, and you may make it start at a suitable stage (for example, when starting annealing). Observation irradiates the light from the light source 66 at a sample 68, and is performed by a detector detecting the reflected light. An example of observation is shown in drawing 7 . Setting to drawing 7 , for Period A, Period B is Si two H6 about sample installation and a warm up period. Period C shows an annealing treatment period for an introductory period.
[0041] If an annealing process starts, the reinforcement of the reflected light will decrease rapidly and will be saturated after that, so that clearly from drawing 7 . Each [of C1, C2, C3, and C4 of drawing] four samples which end annealing treatment at the event were produced, and the front face was observed with the electron microscope. The result is shown in drawing 8 (a), (b), (c), and (d). Here, drawing 8 (a), (b), (c), and (d) correspond to the sample which ended annealing by C1, C2, C3, and C4 of drawing 7 , respectively.
[0042] As shown in drawing 8 (a), (b), and (c), the grain size of HSG-Si accompanying the strength reduction (C1 ->C2 ->C3) of the reflected light has observed buildup. Moreover, as shown in drawing 8 (c) and (d), change of the grain size of HSG-Si was not seen in the field (C3 ->C4) in which the reinforcement of the reflected light is saturated. Moreover, the capacitor was produced using these samples and the stored charge capacity was measured. The result is shown in drawing 9 . As shown in drawing 9 , rapid buildup of stored charge capacity is seen in the field in which the reinforcement of the reflected light decreases (C1 ->C2 ->C3), and stored charge capacity is also saturated with the field (C3 ->C4) in which the reinforcement of the reflected light is saturated.
[0043] Thus, in this example, forming HSG-Si, in situ observation is possible and the stored charge capacity when producing a capacitor from the measured reflection factor can be presumed.
[0044] In addition, although light with a wavelength of 365nm was used in the above-mentioned example, as long as it is within the limits of 240-500nm, the light of other wavelength is sufficient. Moreover, not the light of single wavelength but the light of the wavelength range which has a certain range may be used.
[0045] Moreover, although the above-mentioned example explained the example which built the measuring device into single-wafer-processing equipment, as shown in drawing 10 , it is also incorporable into the batch-processing equipment of hot wall structure. Here, in the equipment of drawing 10 , the same number is given to drawing 6 and a functional target at the same thing.
[0046]

[Effect of the Invention] According to this invention, by having used 240-500nm light, easy and precision are good and it can act as the monitor of the front face of a semi-conductor thin film. It seems that moreover, it does not have an adverse effect on the property as a device of a sample by Itsuko with such a light.
[0047] Moreover, by including the light source and a detecting element in semiconductor fabrication machines and equipment, in situ observation is possible, the processing time is shortened, and improvement in a throughput can be aimed at.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram of the measuring device used for the 1st example of this invention.
[Drawing 2] It is the graph which shows relation with the reflection factor of the front face of a next amorphous silicon before forming a hemispherical grain, the wavelength of light measured using the equipment of drawing 1 , and.
[Drawing 3] It is the graph which shows the relation of the processing time of each process and the reflection factor which were measured using the equipment of drawing 1 , and the relation between the processing time of each process, and the stored charge capacity of the capacitor produced after that, and (a) is Si two H6. (b) is N2 when changing the time amount to expose. The case where the heat treatment time amount under an ambient atmosphere is changed is shown.
[Drawing 4] It is a conceptual diagram for explaining the relation between the formation condition of a hemispherical grain, and that of a reflection factor, and (d) shows the case where the grains which, as for

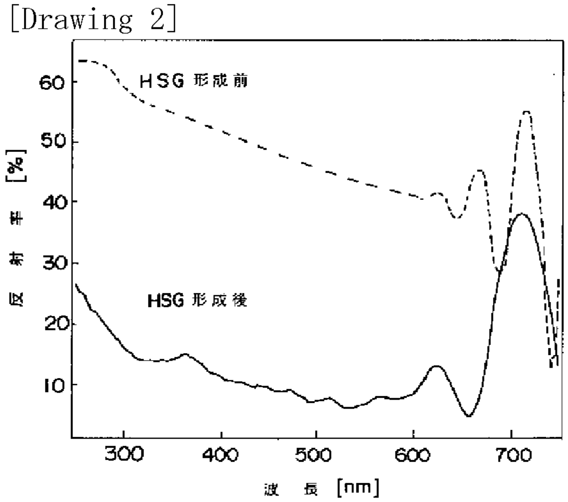
(b), (c) shows the case where a grain is high density to, respectively when a grain is a low consistency, and a grain is semi-gross density, and (a) adjoins join.
[Drawing 5] It is the cross section of DRAM in preparation [for explaining the 2nd example of this invention].
[Drawing 6] It is used for the 3rd example of this invention, and is the schematic diagram of semiconductor fabrication machines and equipment.
[Drawing 7] It is the graph which shows the relation of the grain formation time amount and the surface reflection factor which were measured using the equipment of drawing 6 .
[Drawing 8] (a), (b), (c), and (d) are the microphotographies of the particulate structure of the grain formed in the front face of the electrode at the event of C1, C2, C3, and C4 of drawing 7 , respectively.
[Drawing 9] It is the graph which shows the relation between annealing time amount and stored charge capacity.
[Drawing 10] It is the schematic diagram of other semiconductor fabrication machines and equipment which can be used for the 3rd example of this invention.
[Drawing 11] It is process drawing for explaining the production process of the conventional DRAM.
[Drawing 12] It is the cross section showing the structure of DRAM.
[Drawing 13] It is the microphotography of the particulate structure of the grain formed on the surface of the electrode, and when a grain is formed after (a) fully removed the natural oxidation film of an electrode surface, it shows the case where a grain is formed without (b) fully removing the natural oxidation film of an electrode surface.
[Description of Notations]
11 Sample
12 Sample Base
13 Light Source Section
14 Optical-Axis System Part
15 Spectroscope
16 Data-Processing Section
41 Light Source
42 Detector
51 Silicon Nitride
61 Gas Installation Port
62 Evacuation Port
63 Chamber
64 Sample Base
65 Heater

66 Light Source
67 Detector
68 Sample
101 High Concentration Impurity Diffused Layer
102 Isolation Insulator Layer
103 Gate Electrode
104 P Type Silicon Substrate
105 Interlayer Insulation Film
106 Contact Hole
107 Amorphous Silicon Film
108 Stack Electrode
109 Hemispherical Grain (HSG-Si)

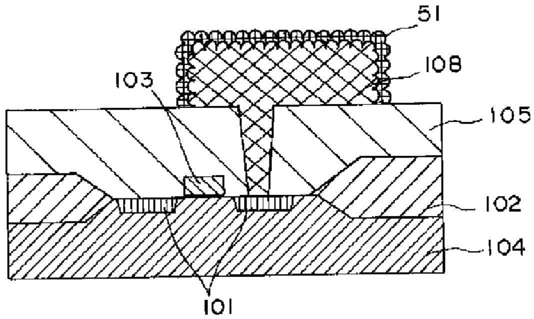
[Translation done.]

DRAWINGS

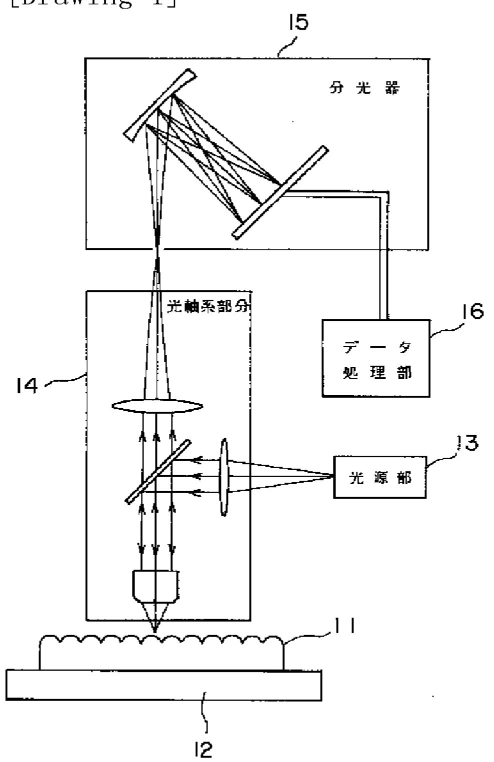
[Drawing 2]



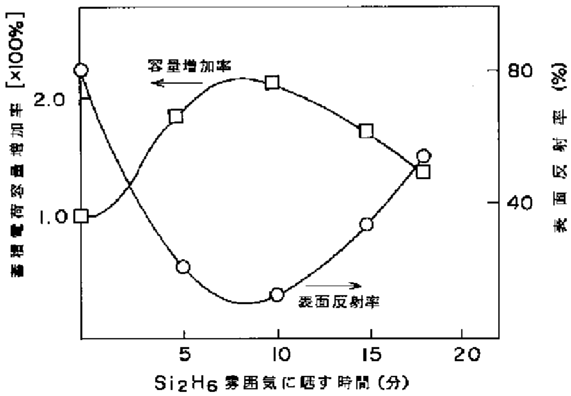
[Drawing 5]



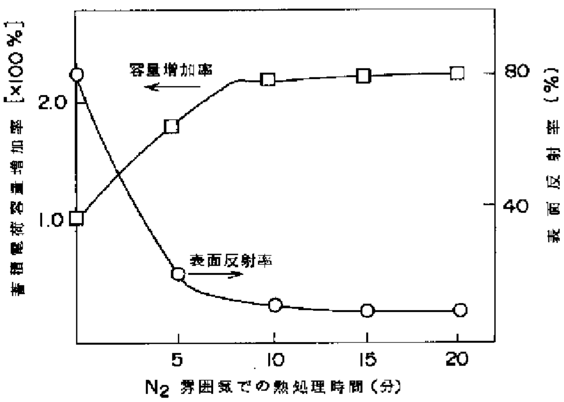
[Drawing 1]



[Drawing 3]

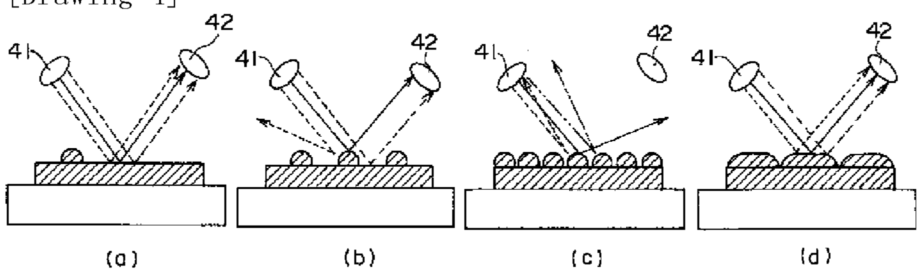


(a)

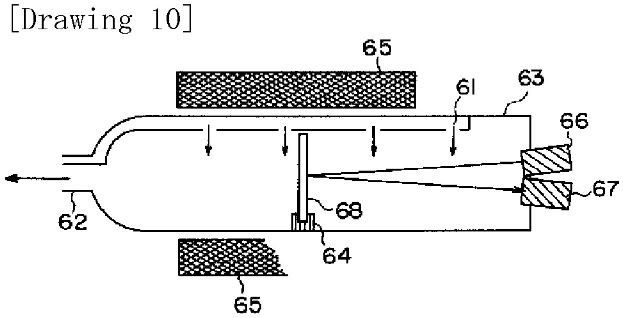


(b)

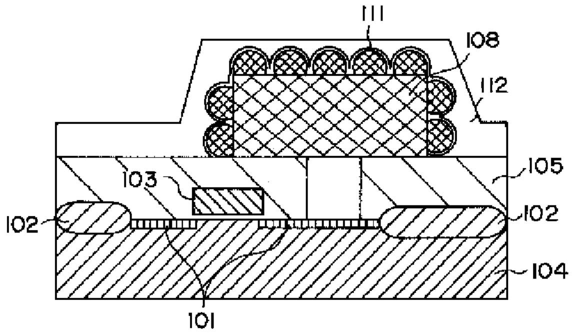
[Drawing 4]



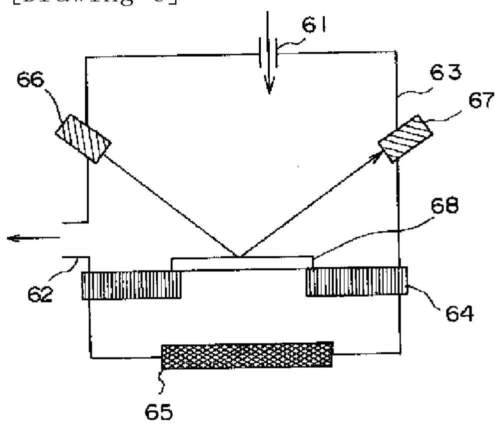
[Drawing 10]



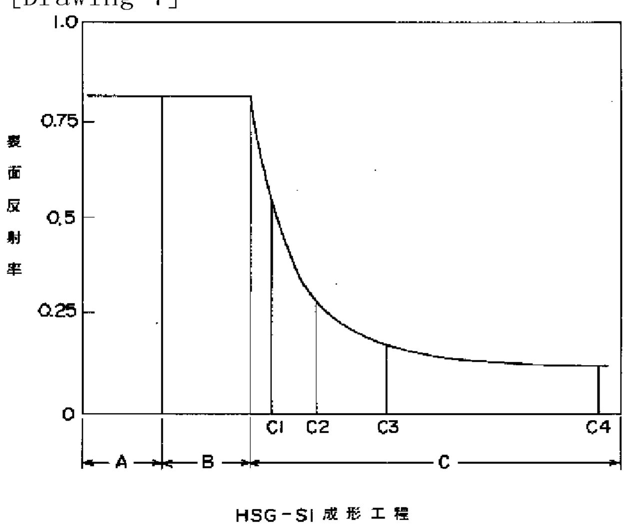
[Drawing 12]



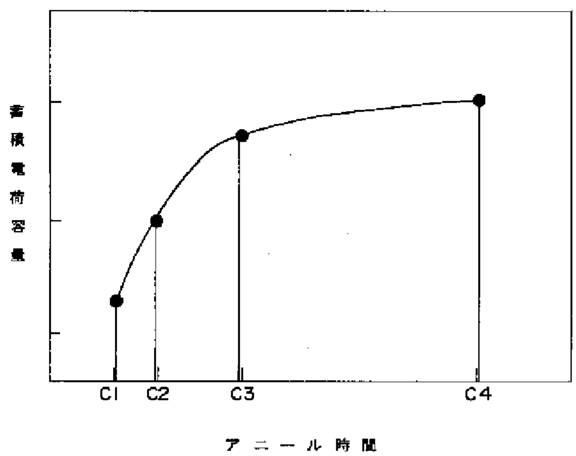
[Drawing 6]



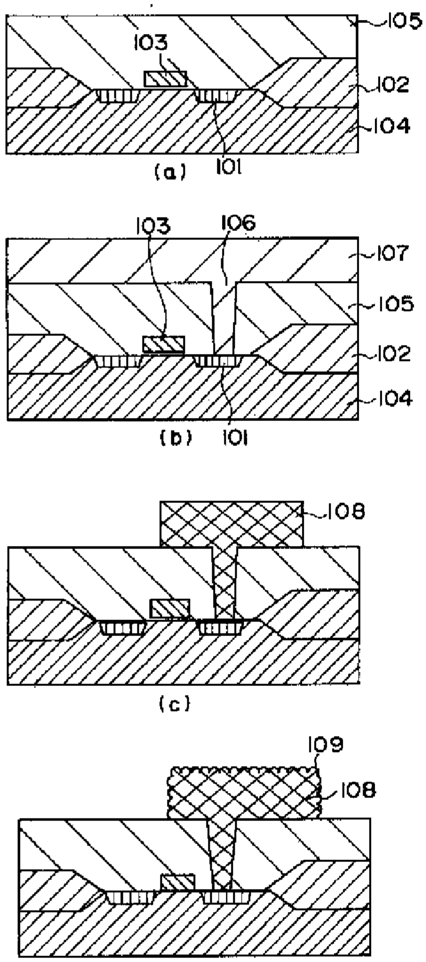
[Drawing 7]



[Drawing 9]

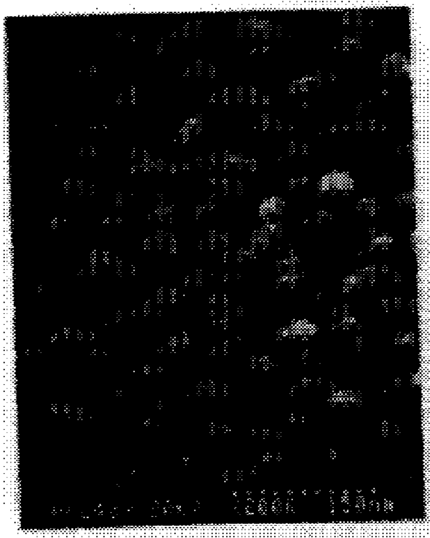


[Drawing 11]



[Drawing 8]

図面代用写真



(a)

(b)

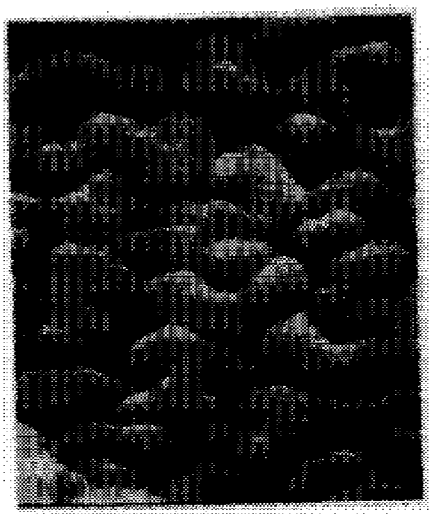
(c)

(d)

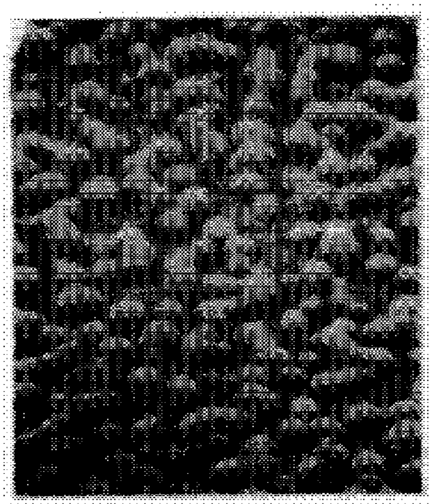
写 真

[Drawing 13]

図版代用写真



（a）



（b）

写　　真

[Translation done.]